Import Risk Analysis: Specified marsupials and monotremes from Australia.

DRAFT READY FOR RISK MANAGEMENT PROPOSAL DEVELOPMENT

November 2014

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Executive summary

This document is a qualitative analysis of the biosecurity risks associated with the importation of specified marsupials and monotremes into New Zealand zoological containment facilities from equivalent facilities in Australia.

From an initial list of all disease-causing organisms associated with marsupials and monotremes, 30 agents were identified as being recorded in Australia, but not present in New Zealand. Of these, 12 organisms were identified as hazards and were subject to individual risk assessments.

As a result of this process, the following agents have been assessed to be risks in marsupials and monotremes and possible control measures to manage these risks have been described:

- Macropod herpesviruses
- Koala retrovirus
- Q fever (*Coxiella burnetti)*
- *Leptospira* spp.
- External parasites
- Internal parasites
- Weeds/weed seeds

1. Introduction

This risk analysis has been developed in order to support the Australasian Species Management Programmes managed by the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA) members in New Zealand. Captive breeding within Australasia has been successful, and in order to sustainably manage the population it is necessary to transfer animals between Australia and New Zealand. This will enable genetic diversity to be maintained, birth/sex ratios and social structures to be managed; and therefore ensure that the breeding programmes can successfully continue.

2. Scope and commodity definition

This risk analysis qualitatively examines the risks due to exotic disease-causing organisms associated with the importation of the following specified marsupials and monotremes from Australia:

Marsupials:

Macropods: Red Kangaroo *(Macropus rufus)*
Eastern Grey Kangaroo *(Macropus giganteus)*
Western Grey Kangaroo (*Macropus fuliginosus)*
Swamp Wallaby *(Wallabia bicolour)*
Brush Tailed Rock Wallaby *(Petrogale penicillata)*
Red Necked Wallaby *(Macropus rufogriseus)*

Other: Common Wombat (*Vombatus ursinus)*
Southern Hairy Nosed Wombat *(Lasiorhinus latifrons)*
Koala *(Phascolarctos cinereus)*
Feather Tailed Glider *(Acrobates pygmaeus)*
Long Nosed Potoroo (*Potorous tridactylus)*

Monotremes:

Short Beaked Echidna (*Tachyglossus aculeatus*) also known as Spiny Anteater.

The risk analysis does not consider speculative events that could occur in the future, such as the possible establishment of disease vectors (for example *Culicoides* spp.) due to climate change. MPI has the ability to modify any Import Health Standards based on a change in the risk profile when appropriate.

All marsupials and monotremes imported into New Zealand must be directed into permanent zoological containment facilities. Marsupials and monotremes must have been born in, and remained in, a government registered or licensed zoo or wildlife park.

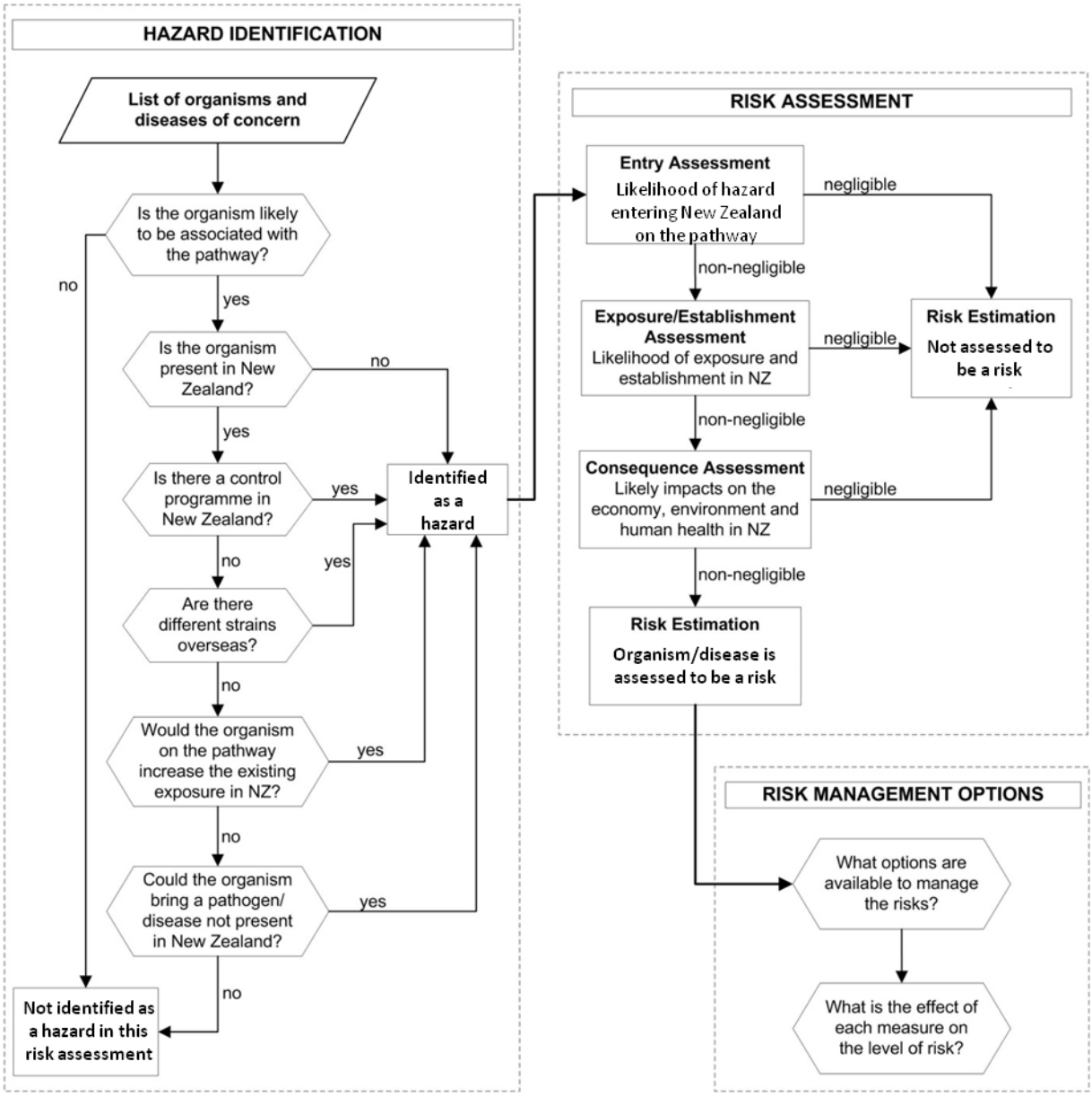
To be eligible for import the Biosecurity Act 1993 requires MPI to be satisfied that the imported animals do not harbour potentially harmful organisms. A pre-arrival requirement of current Import Health Standards is that animals must be certified on the day of travel to be showing no clinical signs of infectious or parasitic disease.

3. Risk analysis methodology

The methodology used in this risk analysis follows the guidelines as described in *Biosecurity New Zealand Risk Analysis Procedures – Version 1* (Biosecurity New Zealand 2006) and in Section 2 of the *Terrestrial Animal Health Code* of the World Organisation for Animal Health (hereafter referred to as the *Code*) (OIE 2011).

The risk analysis process used by the Ministry for Primary Industries (MPI) is summarised in Figure 1.

Figure 1. The risk analysis process



3.1. RISK ASSESSMENT

Risk assessment consists of:

a) *Entry assessment*: The likelihood of a hazard being imported with the animal.
b) *Exposure assessment*: The likelihood of animals or humans in New Zealand being exposed to the hazard.
c) *Consequence assessment*: The consequences of entry, establishment or spread of an imported hazard.
d) *Risk estimation*: An estimation of the risk posed by the hazard based on the entry, exposure and consequence assessments. If the risk estimate is non-negligible, then the hazard is assessed to be a risk and risk management measures are justified to effectively manage the risk.

Not all of the above steps may be necessary in all risk assessments. The OIE methodology makes it clear that if the likelihood of entry is negligible for a certain hazard, then the risk estimate is automatically negligible and the remaining steps of the risk assessment need not be carried out. The same situation arises when the likelihood of entry is non-negligible but the exposure assessment concludes that the likelihood of exposure to susceptible species in the importing country is negligible, or when both entry and exposure are non-negligible but the consequences of introduction are concluded to be negligible.

3.2. RISK MANAGEMENT

For each organism classified as a risk, a risk management step is carried out, which identifies the options available for managing the risk. Where the *Code* lists recommendations for the management of a risk, these are described alongside options of similar, lesser, or greater stringency where available. In addition to the options presented, unrestricted entry or prohibition may also be considered for all risks. Recommendations for the appropriate sanitary measures to achieve the effective management of risks are not made in this document. These are determined when an Import Health Standard is drafted.

As obliged under Article 3.1 of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement), the measures adopted will be based on international standards, guidelines and recommendations where they exist, except as otherwise provided for under Article 3.3 (where measures providing a higher level of protection than international standards can be applied if there is scientific justification, or if there is a level of protection that the member country considers is more appropriate following a risk assessment).

3.3. RISK COMMUNICATION

After an import risk analysis has been written, MPI analyses the options available and proposes draft measures for the effective management of identified risks. These are then presented in a draft Import Health Standard that is released together with a Risk Management Proposal that summarises the options analysis, the rationale for the identified measures and a link to the draft risk analysis.

The package of documents is released for a six-week period of stakeholder consultation. Stakeholder submissions in relation to these documents are reviewed before a final IHS is issued.

4. Preliminary hazard list

The process of hazard identification begins with the collation of a list of organisms that might be associated with marsupials and monotremes. The diseases of interest are those that are exotic to New Zealand, endemic to Australia, and could be transmitted by marsupials or monotremes, and that could infect domestic, feral or wild animals, or humans in New Zealand. In this case an initial list was made of all organisms that may infect marsupials and monotremes mentioned in the following sources:

- Vogelnest L, Woods R (Eds.) *Medicine of Australian Mammals* (2008).
- Marsupialia and Monotremata In: Fowler ME, Miller RE (Eds.) *Zoo and Wild Animal Medicine* (2003).
- *Wildlife Pathology Short Course Proceedings* Australian Registry of Wildlife Health (2008).
- AQIS Interim Conditions for the Importation of Marsupials and Monotremes (1999).
- *OIE* 2008 listings of exotic diseases present in Australia.
- Internet database search for diseases reported in marsupials and monotremes, and for those diseases presence in Australia.

In line with previous MPI import risk analyses for live animals, weed seeds were also included in this list. The organisms of potential concern associated with marsupials and monotremes that were identified in these sources are listed in Table 1.

Table 1. Organisms of Potential Concern

ORGANISM	NEW ZEALAND STATUS	AUSTRALIA STATUS	SPECIES AFFECTED	PRELIMINARY HAZARD?
VIRUSES				
Putative Adenovirus	Endemic	Endemic	Short beaked echidna (subclinical)	No
Cytomegalovirus	Endemic	Endemic	Macropods (subclinical)	No
Herpesviruses	Exotic	Endemic	Macropods, short-beaked echidna, wombat, long-nosed potoroo	Yes
Koala Retrovirus	Exotic	Endemic	Koala	Yes
Murray Valley encephalitis virus	Exotic	Endemic	Macropods	Yes
Papilloma viruses	Exotic?	Endemic	Macropods, koala, short-beaked echidna	Yes
Pox viruses	Exotic	Endemic	Macropods, short-beaked echidna	Yes
Ross River and Barmah Forest viruses	Exotic	Endemic	Macropods, koala	Yes
Wallal and Warrego viruses	Exotic	Endemic	Macropods	Yes

Table 1 (continued)

ORGANISM	NEW ZEALAND STATUS	AUSTRALIA STATUS	SPECIES AFFECTED	PRELIMINARY HAZARD?
BACTERIA				
Aeromonas spp.	Endemic	Endemic	Short-beaked echidna	No
Bartonella australis	Exotic	Endemic	Kangaroo	Yes
Bordetella bronchiseptica	Endemic	Endemic	Wallaby macropods koala	No
Burkholderia pseudomallei (Meliodosis)	Exotic	Endemic	Wallaby, koala	Yes
Campylobacter spp.	Endemic	Endemic	Macropods	No
Chlamydophila pneumonia and *C. pecorum*	Endemic	Endemic	Koala	No
Chromobacterium violaceum	Endemic	Endemic	Wallaby	No
Clostridium piliforme (Tyzzers disease)	Endemic	Endemic	Common wombat, koala,	No
C. tetani (tetanus)	Endemic	Endemic	Macropods	No
C.perfringens	Endemic	Endemic	Macropods	No
*Coxiella burnetti (*Q fever)	Exotic	Endemic	Marsupials	Yes
Dermatophilus spp.	Endemic	Endemic	Macropods	No
Edwardsiella spp.	Endemic	Endemic	Short-beaked echidna	No
Erysipelothrix rhusipathiae	Endemic	Endemic	Macropods	No
Escherichia coli	Endemic	Endemic	All spp.	No
Fusobacterium necrophorum ('Lumpy Jaw' may also involve *Bacteroides (Dichelobacter) nodosus, Actinomyces* spp. or *Corynebacterium* spp.)	Endemic	Endemic	Macropods	No
Helicobacter spp.	Endemic	Endemic	Macropods	No
Klebsiella spp	Endemic	Endemic	Macropods	No
Leptospira spp.	6 serovars endemic	22 serovars endemic	Macropods, wombat, koala	Yes
Listeria monocytogenes	Endemic	Endemic	Macropods	No
Mycobacteriosis many different soil spp.	Endemic	Endemic	Macropods, koala, feather tailed glider, short-beaked echidna	No
Nocardia spp.	Endemic	Endemic	Macropods	No
Pasturella multocida	Endemic	Endemic	Macropods	No
Proteus spp.	Endemic	Endemic	Macropods, short-beaked echidna	No
Pseudomonas spp.	Endemic	Endemic	Macropods, koala, feather-tailed gliders	No
Rickettsia spp.	Exotic	Endemic	Marsupials, echidna	Yes

Table 1 (continued)

ORGANISM	NEW ZEALAND STATUS	AUSTRALIA STATUS	SPECIES AFFECTED	PRELIMINARY HAZARD?
BACTERIA (continued)				
Salmonella spp.	Some exotic	Some exotic	Macropods, koala, short-beaked echidna	Yes
Serratia maracescens	Endemic	Endemic	Koala	No
Shigella spp.	Endemic	Endemic	Wallaby	No
Staphylococcus and *Stretococcus* spp.	Endemic	Endemic	Macropods, koala, short-beaked echidna, koala	No
Yersinia spp.	Endemic	Endemic	Macropods	No
FUNGI				
Candida spp.	Endemic	Endemic	Macropods, feather-tailed gliders, wombat, short-beaked echidna	No
Cryptococcus neoformans	Endemic	Endemic	Macropods, koala, feather-tailed glider, long-nosed potoroo, short-beaked echidna	No
Microsporum (ringworm), *Trichophyton*, *Trichoderma* and *Alternaria* spp.	Endemic	Endemic	Macropods, koala, short-beaked echidna	No
Emmonsia (Chrysosporium) parvum	Endemic	Endemic	Wombats	No
Pneumocystis jiroveci (carinii)	Endemic	Endemic	Kangaroo, wombat	No
Aspergillosis spp.	Endemic	Endemic	Macropods	No
PROTOZOA				
Babesia spp. *Babesia tachyglossi*	Exotic	Endemic	Macropods Short-beaked echidna	Yes
Besnoitia-like spp.	Endemic	Endemic	Eastern grey kangaroo	No
Toxoplasma gondii	Endemic	Endemic	All species	No
Coccidia	Some exotic	Endemic	Macropods, wombat, short-beaked echidna	Yes
Cryptosporidium spp.	Endemic	Endemic	Red and Eastern Grey Kangaroo	No
Entamoeba spp. (Amoebiasis)	Endemic	Endemic	macropods	No
*Leishmania (*undescribed spp)	Exotic	Endemic	Red kangaroo	Yes
Theileria tachyglossi	Exotic (non path endemic)	Endemic	Short-beaked echidna	Yes
Sarcocystis spp.	Endemic	Endemic	Macropods	No
Trypanosoma spp	Exotic	Endemic	Eastern Grey kangaroo	Yes
Hepatozoan tachyglossi	Exotic	Endemic	Short-beaked echidna	Yes
PARASITES				
Ticks	9 spp. endemic (8 avian)	75 spp. endemic	800+ spp. worldwide	Yes
Mites				
Sarcoptes Scabeii	Endemic	Endemic	All species	No
Trombiculid spp. *Dermanyssid* spp.	Exotic	Endemic	Kangaroo, wombat, koala, echidna	Yes
Demodex spp.	Endemic	Endemic	Echidna, koala	No
Other spp.	Exotic	Endemic	Echidna, koala	Yes

Table 1 (continued)

ORGANISM	NEW ZEALAND STATUS	AUSTRALIA STATUS	SPECIES AFFECTED	PRELIMINARY HAZARD?
PARASITES (continued)				
Lice, various spp.	Exotic	Endemic	Macropods, wombats	Yes
Stick-fast fleas *Echidnophaga* spp.	Exotic	Endemic	Macropods, wombats	Yes
cat fleas	Endemic	Endemic	Koala	No
other spp.	Exotic	Exotic	Various	Yes
Flies *Hippoboscid*	Endemic	Endemic	All marsupials	No
spp	Exotic	Endemic	Kangaroo bot-fly	Yes
Tracheomyia macropi	Exotic	Endemic	Kangaroo/wallaby sandfly	Yes
Austrosimulium pestilens *Simulium ornatipes* *Lucilia cuprina* (sheep blowfly)	Endemic	Endemic	Koala cutaneous myiasis (flystrike)	No
Nematodes multiple species	Some exotic	Endemic	All marsupials and monotremes.	Yes
Trematodes	Some exotic	Endemic	All marsupials and monotremes.	Yes
Cestodes multiple species	Some exotic	Endemic	All marsupials and monotremes	Yes
MISCELLANEOUS				
weeds and weed seeds	Some exotic	Some exotic	All marsupials and monotremes	Yes

The preliminary hazard list for the defined commodity is therefore as follows:

4.1. VIRUSES

Herpesviruses	Macropods, echidna, wombat
Koala Retrovirus	Koala
Murray Valley encephalitis virus	Macropods
Orbiviruses	Macropods
Papilloma virus	Macropods, echidna, koala
Pox virus	Macropods, echidna
Ross River Fever and Barmah Forest viruses	Macropods, koala

4.2. BACTERIA

Bartonella australis	Kangaroo
Burkholderia pseudomallei	Wallaby, koala
Coxiella burnetti (Q Fever)	Most marsupials
Rickettsia spp.	Most marsupials, echidna
Leptospira spp.	Macropods, wombat
Salmonella spp.	Macropods, koala, echidna

4.3. PROTOZOAL ORGANISMS

Babesia spp. and *Theileria* spp.	Kangaroo, echidna
Coccidia spp.	Macropods, wombat, echidna
Leishmania, *Trypanosoma*, and *Hepatozoan* spp.	Kangaroo, echindna

4.4. INTERNAL PARASITES

Nematodes	All species
Cestodes	All species
Trematodes	All species

4.5. EXTERNAL PARASITES

Ticks	All species
Mites	All species
Lice	Marsupials
Fleas	All species
Bot Fly	Kangaroo

4.6. MISCELLANEOUS

Weeds and weed seeds	All species

References

References marked * have been sighted as summaries in electronic media. All weblinks were accessed in November 2008**.**

AQIS (1999) Interim Conditions for the Importation of Marsupials http://www.aqis.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8754626&intCommodityId=15826&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

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5. Herpesviruses

5.1. HAZARD IDENTIFICATION

5.1.1. Aetiological agents

Family: *Herpesviridae* Subfamily: *Alphaherpesvirinae* Genus: *Varicellovirus*

Macropod herpesviruses are designated into two strains, one MaHV-1 and eight MaHV-2 isolated types (Vogelnest and Portas 2008). At least one other as yet uncharacterised strain has been identified (Guliani *et al*. 1999).

5.1.2. OIE list

Not listed.

5.1.3. New Zealand status

There are no reports of herpesviruses being isolated from captive macropods in New Zealand. Free-living wallabies on Kawau island also tested negative for herpesvirus antibodies, and no viruses were isolated (Duignan *et al*. 2004).

5.1.4. Epidemiology

Macropod herpesviruses are assumed to occur throughout Australia, but disease attributable to herpesviruses has only been reported in captive macropods. A range of species have been affected including red, eastern and western grey kangaroos, several wallaby species and long-nosed potoroos (Vogelnest and Portas 2008).

The clinical course of infection can be variable, with acute death in some individuals, and a more protracted course of up to a week in others (Vogelnest and Portas 2008). Clinical signs include conjunctivitis, ocular and nasal discharge, dyspnoea, incoordination, 2-3mm ano-genital vesicles, depression and anorexia (Ladds 2008).

Serological surveys have demonstrated widespread prevalence of neutralising antibodies to macropod herpesviruses, up to 25% in wild populations and between 50-100% in captive populations (Guliani *et al.* 1999). The antibody titres of animals in captivity were generally higher (Webber and Whalley 1978).

Little is known regarding the natural dynamics of these viruses in either wild or captive marsupial populations. It is assumed that all macropod species are potentially susceptible (Vogelnest and Portas 2008).

Latent infection has been demonstrated by reactivation with corticosteroid treatment (immunosuppression) in eastern grey kangaroos. Virus was detectably shed in nasal secretions on days 9-21 days post treatment without observable clinical signs (Guliani *et al*. 1999). The potential exists in relocation programs for the introduction of herpesviruses as the animals may undergo sufficient stress during transport and handling to cause reactivation (Guliani *et al*. 1999).

Diagnosis can be achieved through the demonstration of a rising antibody titre via a serum neutralisation test. Viral culture/isolation from nasal swabs and post-mortem PCR on trigeminal ganglia have also been used (Guliani *et al*. 1999). Some anti-herpes viral compounds have been shown to have inhibitory effects on MaHV-2 *in vitro*, but there are no reports of *in-vivo* use in macropods (Smith 1996).

There is a single report of mortality likely to be due to herpesvirus infection in a juvenile male orphaned wombat (Rothwell and Canfield 1988). Intra-nuclear viral particles morphologically consistent with herpesviridae were observed in hepatocytes, but attempts to isolate virus in cell culture were unsuccessful.

Herpesvirus infection involving multi-systemic disease and inclusion body hepatitis has been reported in short-beaked echidna, but appears to be an infrequent finding (Whittington 1993).

5.1.5. Hazard identification conclusion

There is both a high prevalence and high titres of antibody to herpesviruses in captive macropods. Infection can be latent, and virus can be shed without clinical signs.

Therefore, macropod herpesviruses are identified as a hazard in the commodity.

There is insufficient evidence for significance of herpesvirus infection in wombats and short-beaked echidna, therefore they are not identified as a hazard in these commodities.

5.2. RISK ASSESSMENT

5.2.1. Entry assessment

There is a high likelihood that active or latently infected macropods could be imported without observable clinical signs. Therefore, the likelihood of entry is assessed to be non-negligible.

5.2.2. Exposure assessment

Transmission has not been fully characterised, but viral shedding demonstrated in nasal secretions suggests a respiratory route (Vogelnest and Portas 2008). Naïve macropods in direct contact with introduced infected animals, or in contact with a contaminated environment could become infected.

The stress of handling and transportation involved in importing animals is likely to reactivate latent herpesvirus infections, inducing viral shedding for up to 21 days post arrival. Therefore the likelihood of exposure is assessed to be non-negligible.

5.2.3. Consequence assessment

Herpesviruses are species specific. New Zealand has no native macropods, but there are both captive and free-living populations of wallabies. There are no reports of clinical disease or herpesvirus isolation from any macropod population in New Zealand.

Free-living wallabies are considered to be pests by some regional councils, but are not designated unwanted organisms. Management of them is region specific under Regional Pest Management Strategies (RPMS). The aim of Auckland City Councils RPMS is eradication of

wallabies from the region (Brunton 2009). Therefore the consequences are restricted to New Zealand's captive macropod population.

A spectrum of clinical signs from mild conjunctivitis to significant respiratory distress or death can result, and recovered animals are persistently infected. It is likely that disease would be regularly seen during times of stress, and would potentially involve large numbers of animals. The consequences for New Zealands captive macropod population are assessed to be non-negligible.

5.2.4. Risk estimation

Since entry, exposure, and consequence assessments are non-negligible, the risk estimate for macropod herpesviruses is non-negligible and they are assessed to be a risk in the commodity.

5.3. RISK MANAGEMENT

5.3.1. Options

The following measures could be considered in order to manage the risk:

- Macropods could be imported without restriction. As there are no consequences for other animal or human populations in New Zealand, individual zoo importers could choose to manage herpesvirus infection as a quality issue.
- Macropods could be certified as being born or permanently resident in establishments where no evidence of herpesvirus has been detected.
- Macropods could be held in quarantine for at least the 30 days prior to shipment and show no clinical signs of herpesvirus.
- Macropods could be serologically tested for herpesvirus antibodies, and must test negative to be eligible for import due to the high likelihood of latent infection.

References

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Duignan PJ, Norman RJ, O'Keefe J, Horner G (2004) Health assessment of wallabies from Kawau Island. *Surveillance*, 31(1), 16-18.

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Whittington RJ (1993) Diseases of Monotremes In: Fowler ME (ed). *Zoo and Wild Animal Medicine, Current Therapy 3*, WB Saunders, Philadelphia, 269-275.

6. Koala retrovirus

6.1. HAZARD IDENTIFICATION

6.1.1. Aetiological agent

Family: *Retroviridae* Genus: *Gammaretrovirus* Species: *Koala Retrovirus* (KoRV)

6.1.2. OIE list

Not listed.

6.1.3. New Zealand status

Exotic.

6.1.4. Epidemiology

Members of the family Retroviridae are able to reverse transcribe their single-stranded RNA genomes into double-stranded DNA intermediates that are then integrated into the host cell genome as part of the normal virus life cycle. If integration occurs in germ line cells or early-stage embryos, they become endogenous retroviruses that can be transmitted vertically (Gifford and Tristem 2003).

KoRV occupies a rare status, as it behaves very much like an exogenous virus and is also present as an endogenous virus; this duality increases the likelihood of self-activation and recombination (Oliveira *et al*. 2006).

KoRV is present and actively expressed within koalas sampled from both captive and free-ranging habitats on mainland Australia. Recently, a population of KoRV-free koalas was discovered on Kangaroo Island. These animals have been sequestered from the mainland koalas since the 1920s, suggesting that the infection and endogenisation of KoRV among mainland koalas are recent events (Tarlinton *et al*. 2005a).

Research has demonstrated a positive association between plasma levels of KoRV RNA and diseases common in koalas, particularly leukaemia, lymphoma, and chlamydiosis (Tarlinton *et al*. 2005b). Koalas suffer from a high incidence of leukaemia and lymphoma, with reported rates at necropsy of 3 to 5% in the wild and up to 60% in some captive colonies (Hanger *et al*. 2000). Koalas are also particularly susceptible to chlamydiosis, a disease that is commonly associated with immunosuppression in other species.

There is a correlation between plasma levels of KoRV RNA and the development of diseases suggestive of immunodeficiency such as stomatitis, glossitis, pharyngitis, fungal dermatopathies and some gastrointestinal disorders (Hanger *et al*. 2003).

The prevalence of KoRV varies across the range of koalas in Australia. It is present at a prevalence of 100% in Queensland populations, 20-60% in a limited survey of Victorian animals, and not present at all on Kangaroo Island, South Australia (AWHN 2005).

Proviral DNA or viral RNA is detected with PCR. KoRV provirus in sperm can also be detected, but these tests are not currently available commercially. No treatment or vaccine is

available and very little is known about the transmission potential of the virus. It should be noted that KoRV viral loads in infected zoo populations are not simply inherited and thus using animals of low viral load for breeding is not likely to decrease the risk of disease (AWHN 2005).

6.1.5. Hazard identification conclusion

Because there is a high prevalence of infection, and infected koalas may not show obvious clinical signs, KoRV is identified as a hazard in imported koalas.

6.2. RISK ASSESSMENT

6.2.1. Entry assessment

Koalas infected with endogenous KoRV carry the virus for life, and prevalence in some regions of Australia is very high. Therefore the likelihood of introducing KoRV is non-negligible.

6.2.2. Exposure assessment

Transmission is vertical and also suspected to be horizontal, as with other retroviruses. The virus is known to be present in semen, and imported koalas will partake in breeding programmes.

There are currently no koalas present in New Zealand zoos, and KoRV has not been found in other species. However, a recent publication hypothesises that an intermediate vector such as rodents may facilitate cross-species transmission of the virus (Fiebig *et al.* 2006).

KoRV-like viruses have been found in Asian rodents, and an Australian native rodent species, and it is thought that KoRV originated in rodents and crossed to koalas, rather than the other way around. There is also good evidence that KoRV can replicate when injected into rats, but it is not known whether natural transmission occurs (Tarlinton 2009).

Therefore, the likelihood of exposure is assessed to be very low.

6.2.3. Consequence assessment

KoRV-related viruses have not been detected in other marsupials, and phylogenetic analysis shows that KoRV paradoxically clusters with gibbon ape leukemia virus (GALV). The strong similarity between GALV and KoRV suggests that these viruses are closely related and that recent cross-host transmission has occurred (Hanger *et al.* 2000).

Both KoRV and GALV replicate in human cell lines but there is a large body of evidence from other endogenous retroviruses that cross species transmission is very rare, and that replicating in cell culture does not correspond with replication in the whole animal. There have also been no reports of KoRV or GALV infection in lab workers or animal handlers (Tarlinton 2009).

As there is not an existing population of koalas in New Zealand zoos, there are no immediate consequences. However, if the founding imported population is infected with KoRV, the consequences are on-going immunosuppressive related diseases, and high incidences of

neoplasia. There is also a small potential for cross species transmission, and consequently immunosuppressive disease may impact other species.

Therefore the consequences for New Zealands founder koala population, and the consequences of potential infection in other species are assessed to be non-negligible.

6.2.4. Risk estimation

Since entry, exposure, and consequence assessments are non-negligible, the risk estimate for KoRV is non-negligible and is classified as a risk in imported koalas.

6.3. RISK MANAGEMENT

6.3.1. Options

The following measures could be considered in order to manage the risk:

- Koalas could be imported without restriction. As there are no existing koala populations in New Zealand and the likelihood of cross-species transmission is very low, individual zoo importers could choose to manage KoRV infection as a quality issue.

- Koalas could be certified as being born or permanently resident in establishments where no evidence of KoRV has been detected.

- Koalas could be certified as showing no clinical signs of disease suggestive of immunodeficiency prior to export. A complete (lifetime) health record could be provided for each koala.

- Koalas could be serologically tested by PCR for KoRV RNA or DNA, and must test negative to be eligible for import.

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7. Murray Valley encephalitis virus

7.1. HAZARD IDENTIFICATION

7.1.1. Aetiological agent

Family: *Flaviviridae* Genus: *Flavivirus* Species: *Murray Valley Encephalitis* (MVE)

7.1.2. OIE list

Not listed.

7.1.3. New Zealand status

Exotic, listed on the unwanted organisms register.

7.1.4. Epidemiology

MVE is endemic in northern Western Australia and in the Northern Territory. It is thought to occur in other parts of Australia by the movement of infected native birds or infected mosquitoes. However, there is also evidence that the virus is able to survive in these new areas for at least one or two seasons, possibly within mosquito eggs or by other unidentified mechanisms (DHA 2004).

MVE is an arbovirus that can result in varying levels of disease in humans. Most often infection is subclinical, or causes mild fever, headache, nausea and vomiting. In a small percentage of cases, mild disease is a prodrome to CNS involvement causing meningoencephalitis, and occasionally death. Symptoms of severe disease include drowsiness, confusion, seizures, weakness, or ataxia (DHA 2004).

The incubation period ranges from 7-21 days. There is no evidence of person to person transmission (CDPC 2008). Cases occur sporadically in Northern and Western Australia (Russell 1995).

The primary or reservoir hosts of MVE are water birds, with ardeiformes (herons), and pelicaniformes (cormorants/ darters) the most commonly infected. *Culex annulirostris* is recognised as the major vector of MVEV in Australia. The virus has also been recovered from other mosquito species including *Aedes normanensis*, *Ae. pseudonormanensis*, *Ae. eidsvoldensis*, *Anopheles annulipes*, *Anopheles bancroftii*, *Cx. quinquefasciatus*, *Cx. australicus*, *Cx. palpalis*, and *Monsonia uniformis* (Mackenzie et al 1994; DHA 2004). Of these, only *Cx. quinquefasciatus* (an introduced mosquito species known to be present in New Zealand [Holder 1999]) has been shown experimentally to transmit MVE.

Macropods and domestic animals such as poultry, horses, pigs and cattle may be infected, but their role in natural transmission cycles is not thought to be important (CDNA 2005).

14 Eastern grey kangaroos and 9 agile wallabies were exposed to infection with 4 strains of MVE, mainly using orally infected *Cx. annulirostris* mosquitoes. Antibody titres were found to be high and persistent in grey kangaroos, but low and transient in agile wallabies (Kay *et al.* 1985). It was also shown that average duration of viraemia was 4-6 days, and infection

was transmitted to 10% of mosquitoes allowed to feed on the eastern grey kangaroos, with some individuals infecting up to 50%.

Diagnosis in humans is by virus isolation, RNA or antibody detection (DHA 2004).

7.1.5. Hazard identification conclusion

Seropositive kangaroos have been detected in Australia that are capable of transmitting infection to mosquitoes. There is experimental evidence that competent vectors may be present in New Zealand, and disease in humans can be severe. Therefore Murray Valley encephalitis virus is identified as a hazard in the commodity.

7.2. RISK ASSESSMENT

7.2.1. Entry assessment

MVE could only be introduced into New Zealand by animals that are in the incubation period or viraemic at the time of introduction. There are no clinical signs associated with infection in macropods, and individuals may be infectious for some time. Therefore the likelihood of introducing incubating or viraemic animals is assessed to be low.

7.2.2. Exposure assessment

A viraemic animal introduced into New Zealand would not be directly infectious. MVE could only be transmitted to other animals or humans in New Zealand by competent insect vectors. The main vector species in Australia (*Cx. annulirostris*) does not occur in New Zealand, although other competent vectors may be present.

The likelihood of a competent vector mosquito biting a viraemic imported macropod and then transmitting MVE to susceptible animals or humans is very low.

7.2.3. Consequence assessment

The significance of importing macropods infected with MVE would probably be related only to its zoonotic potential. The number of potentially infected humans from Australia far exceeds the number of macropods imported annually.

Most human infections are subclinical, and there have been no case reports in New Zealand according to data collected since 1997(ESR 2009).

There are currently no risk management measures applied to importation of other animals potentially infected with MVE from Australia, and no incursions have been reported.

Therefore, the likelihood of significant consequences is negligible.

7.2.4. Risk estimation

Because the consequence assessment is negligible, the risk estimate for MVE is negligible, and the virus is not assessed to be a risk in the commodity.

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8. Macropod orbiviruses

8.1. HAZARD IDENTIFICATION

8.1.1. Aetiological agent

Family: *Reoviridae* Genus: *Orbivirus* Species: *Wallal virus* (WALV), *Warrego virus* (WARV). There are 3 known serotypes of each.

8.1.2. OIE list

Not listed.

8.1.3. New Zealand status

There are no reports of evidence of infection with orbiviruses in macropod populations in New Zealand.

8.1.4. Epidemiology

Viral chorioretinitis ('kangaroo blindness') associated with WALV and possibly WARV has been reported in macropods from southern Queensland, New South Wales, Victoria, Western Australia and South Australia (Hooper 1999). WARV appears to be of less significance (Hooper *et al.* 1999). Western and eastern grey kangaroos, red kangaroos and wallaroos are the principal species affected (Durham *et al*. 1996).

WALV and WARV have been detected by PCR in several species of *Culicoides,* which indicates their potential as vectors. The distribution of the disease is also consistent with the distribution of these midges. Other insect species including mosquitoes were negative on PCR testing (Hooper *et al.* 1999).

Disease is associated with increased vector activity in summer, following water courses, and tends to occur in outbreaks (Durham *et al*. 1996). During outbreaks infection is widespread, but often subclinical. Only severely affected animals which become blind are noticeable. Animals are viraemic within several weeks of first infection, and weeks to months before clinical signs appear (AWHN 2004).

The predominant clinical sign of infection is blindness, with all age classes of macropods except pouch young affected. Conjunctivitis and a high-stepping gait are occasionally present (Vogelnest and Portas 2008). In the early stages of infection, there may be no clinical signs other than reduced optic reflectivity at night (Hooper *et al.* 1999).

Histopathological findings are retinitis and a severe bilateral non-suppurative panuveitis. Optic neuritis and secondary demyelination of the optic nerves also occurs (Vogelnest and Portas 2008).

A wide range of tests to detect characteristic changes can be performed on eye and brain tissue. Serum neutralisation tests and orbivirus group-specific PCRs can be used to detect the Wallal and Warrego serogroups (Hooper *et al*. 1999).

There have been no reports of kangaroo blindness in captive macropods in Australia (ARWH 2009).

8.1.5. Hazard identification conclusion

Because macropods can be in the early stages of infection without showing obvious clinical signs, WARV and WALV are identified as a hazard in the commodity.

8.2. RISK ASSESSMENT

8.2.1. Entry assessment

WALV and WARV could only be introduced into New Zealand by animals that are in the incubation period or viraemic at the time of introduction. The macropods would need to be imported from an Australian zoo located where the *Culicoides* vector is known to be present. Therefore the likelihood of introducing an incubating or viraemic animal is non-negligible.

8.2.2. Exposure assessment

A viraemic animal introduced into New Zealand would not be infectious. WALV and WARV could only be transmitted to other animals in New Zealand by competent insect vectors. Annual surveys reported in the MPI publication *Surveillance* have demonstrated that *Culicoides* spp. are not present in New Zealand.

A typical report shows that no *Culicoides* spp. were found in 15,000 insects trapped and that serological conversion to arboviruses did not occur in sentinel cattle (Motha *et al.* 1997). Since *Culicoides* spp. are the vectors of the disease it is unlikely that New Zealand macropods would be exposed to the virus. To date, seroconversion to arboviruses has not been detected in sentinel cattle and no *Culicoides* have been trapped.

In the absence of a competent vector in New Zealand, the likelihood of exposure is assessed to be negligible.

8.2.3. Risk estimation

Because the exposure assessment is negligible, the risk estimate for WALV and WARV is negligible, and these viruses are not classified as a risk in the commodity.

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9. Papilloma viruses

9.1. HAZARD IDENTIFICATION

9.1.1. Aetiological agents

Family: *Papillomaviridae*. These viruses have not been characterised further.

Papilloma viruses have been identified in skin lesions and/or on healthy skin of macropods, koalas, and juvenile short-beaked echidnas.

9.1.2. OIE list

Not listed.

9.1.3. New Zealand status

There are no reports of papilloma virus isolation, or indicative lesions from macropods within New Zealand.

9.1.4. Epidemiology

Papillomaviruses (PVs) are small, epitheliotropic, DNA viruses that cause proliferations in skin and mucosa. They have been found in a large number of vertebrate species, including man, and are assumed to have evolved alongside their hosts (Sundberg 1987).

PV infections are highly host specific and no PV type has been shown to have both humans and an animal species as its natural hosts (Chan *et al*. 1997).

Papilloma lesions have been described around the face, eyes, lips and gums of young koalas. PVs have been isolated from the skin of one affected and 9 clinically normal koalas out of 70 tested (Antonsson and McMillan 2006).

Subclinical PV infection was detected by PCR skin swab samples from one out of 5 short-beaked echidnas, and one out of 23 eastern grey kanagaroos tested (Antonsson and McMillan 2006).

Because PVs can be present on healthy skin, some are considered ubiquitous commensals (Antonsson *et al.* 2000). The incubation period or factors contributing to expression of disease in marsupials and monotremes are unknown.

As with poxviruses, infection tends to be self-limiting and the dermal lesions resolve over several months, with no known lasting sequelae.

9.1.5. Hazard identification conclusion

PVs are widely present on the skin of many species of healthy animals, in all countries. As New Zealand macropod populations have not been tested for the presence of PVs, there is no evidence to support a claim of freedom from these viruses.

Therefore, papillomaviruses are not identified as a hazard in the commodity.

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10. Pox viruses

10.1. HAZARD IDENTIFICATION

10.1.1. Aetiological agents

Family: *Poxviridae*. These viruses have not been characterised further.

Pox viruses have been identified in papillomatous skin lesions of macropods and juvenile short-beaked echidnas.

10.1.2. OIE list

Not listed.

10.1.3. New Zealand status

Pox viruses in other species are listed on the unwanted organisms register. There are no reports of pox-like skin lesions from macropods within New Zealand.

10.1.4. Epidemiology

Macropod pox lesions have been reported in red, eastern grey and western grey kangaroos (Arundel *et al*. 1979; McKenzie *et al*. 1979; Rothwell *et al*. 1984).

The macropod pox virus appears to be species specific. In a captive colony composed of several macropod species only eastern greys were affected. Newly introduced eastern grey kangaroo joeys acquired the disease, while other newly introduced macropod species did not. Eastern grey kangaroos also seem to develop lesions in greater numbers and of larger size than other species (Speare 2006).

The incubation period for macropod poxviruses is unknown. In other species including human, sheep and goat pox the incubation period is up to 21days (OIE 2002). Poxviruses can survive for months in the environment, and for years in dried scabs at ambient temperatures.

Lesions vary from single, to multi-focal, to coalescing hyperkeratotic papillomatous proliferations often with a central crater. They occur typically about the head, forelimbs, or tail, usually in juveniles or subadults. Lesions vary in size from a few millimetres up to 5cm diameter (Vogelnest and Portas 2008).

Lesion appearance is characteristic, or biopsies can be submitted for histopathology confirmation. Eosinophilic intracytoplasmic inclusions displacing the nucleus of epidermal cells should diagnose (McKenzie *et al*. 1979).

Treatment is generally not indicated as infection tends to be self-limiting and lesions usually resolve over several months. Surgical excision can be undertaken if the lesion's location compromises function. Strategies for disease prevention other than isolation of naïve pouch young from infected animals have not been developed as the complete epidemiology of the virus is not known (Vogelnest and Portas 2008).

Poxvirus is occasionally found within proliferative dermal lesions in juvenile short-beaked echidna (Whittington 1993). The incidence and significance of infection remain poorly understood (Middleton 2008).

10.1.5. Hazard identification conclusion

Evidence of poxvirus infection (papillomatous lesions) appears to be observed fairly often in captive macropods. Only macropods certified as showing no clinical signs of disease are eligible for import; but it is not known for how long an animal can be infected without showing clinical signs, or for how long an animal remains infective to others.

Therefore, macropod poxviruses are identified as a hazard in the commodity.

There is insufficient evidence for significance of poxvirus infection in short-beaked echidna, therefore poxviruses are not identified as a hazards in echidna.

10.2. RISK ASSESSMENT

10.2.1. Entry assessment

It is assumed that infected macropods could be imported without observable clinical signs. The likelihood of entry is assessed to be non-negligible.

10.2.2. Exposure assessment

Transmission has not been fully characterised, but direct transfer via close contact or via arthropod vectors have been proposed (Vogelnest and Portas 2008). It is likely that naïve macropods in direct contact with introduced infected animals would become infected with the disease. Poxviruses in general survive well in the environment. Therefore the likelihood of exposure is assessed to be non-negligible.

10.2.3. Consequence assessment

Macropod poxviruses appear to be species specific. New Zealand has no native macropods, but there captive populations of macropods and free-living populations of wallabies. There are no reports of papillomatous lesions or poxvirus isolation from any macropod population in New Zealand.

Infection tends to be self-limiting and the dermal lesions resolve over several months, with no known lasting sequelae. Therefore the consequences are assessed to be negligible.

10.2.4. Risk estimation

Because the consequence assessment is negligible, the risk estimate for macropod poxviruses is negligible and they are not assessed to be a risk in the commodity.

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11. Ross River and Barmah Forest viruses

11.1. HAZARD IDENTIFICATION

11.1.1. Aetiological agents

Family: *Togaviridae* Genus: *Alphavirus* Species: *Ross River virus* (RRV), *Barmah Forest virus* (BFV).

11.1.2. OIE list

Not listed.

11.1.3. New Zealand status

Serological studies have shown that RRV has probably been introduced into New Zealand by viraemic travellers on many occasions. Although some local mosquitoes have shown the ability to transmit the virus in the laboratory, there has been no evidence of establishment (Maguire 1994).

11.1.4. Epidemiology

RRV occurs throughout Australia, including Tasmania, and also in Papua New Guinea, the Solomon Islands, New Caledonia, Fiji, American Samoa and the Cook Islands (Aaskov and Dougherty 1994). BFV has been detected in most parts of mainland Australia (DHA 2003).

RRV and BFV are arboviruses causing indistinguishable clinical signs in humans of polyarthritis/arthralgia. Infection is often accompanied by a maculopapular rash and low-grade fever. The incubation period ranges from 3-21 days. Symptoms usually resolve within a month, and there is no evidence that infection with RRV can lead to chronic disease (Harley *et al*. 2001). With BFV infection, lethargy, arthralgia and myalgia can persist for over six months. Infection with either virus can also be subclinical (DHA 2003).

Serological evidence indicates RRV may also be associated with a condition in horses involving muscle and joint stiffness, limb oedema and nervous signs. Experimental inoculation of horses has only resulted in a very mild clinical syndrome (Kay and Aaskov 1989).

Positive antibody titres to RRV and BFV in the absence of clinical signs occur in a broad range of marsupials, mammals and birds (Aaskov and Dougherty 1994). Serological surveys have shown that macropods are the most likely natural vertebrate reservoir host for RRV. Less is known about BFV, but positive antibody titres have also been detected in macropods and koalas (Aldred *et al*. 1991).

A wide variety of mosquito species are capable of transmitting these viruses, at least 30 different species across six genera in Australia, although efficiency varies considerably (AWHN 2009). The most common vector species in Australia *Culex annulirostris* and *Aedes vigilax* don't occur in New Zealand, but several species of the same genera do. One species in New Zealand, *Aedes australis* has been shown to be capable of transmitting RRV under laboratory conditions (Maguire 1994).

Serological studies found that of 39 Eastern Grey Kangaroos tested 74% had positive RRV antibody titres, and 44% had positive BFV antibody titres. From 93 koalas tested, 16% had positive RRV antibody titres, and 9% had positive BFV antibody titres (Aldred *et al*. 1991). Viraemia in wildlife is thought to be short-lived, so virus isolation is seldom possible (Harley *et al*. 2001).

A variety of serological tests are used to diagnose RRV infection in people including: HI, ELISA, CF, and VNT. Virus isolation is possible, but considered to be too slow and expensive for routine diagnostic use (Aaskov and Dougherty 1994). A PCR test is available in Australia (Portas 2009).

11.1.5. Hazard identification conclusion

Because seropositive kangaroos and koalas have been detected in Australia, and New Zealand has potentially competent mosquito vectors, Ross River virus and Barmah Forest virus are identified as a hazard.

11.2. RISK ASSESSMENT

11.2.1. Entry assessment

RRV and BFV could only be introduced into New Zealand by animals that are in the incubation period or viraemic at the time of introduction. There are no clinical signs associated with infection in marsupials, and the precise time-course of infection is unknown. Therefore the likelihood of introducing incubating or viraemic animals is low.

11.2.2. Exposure assessment

A viraemic animal introduced into New Zealand would not be directly infectious. RRV and BFV could only be transmitted to other animals or humans in New Zealand by competent insect vectors. One mosquito species in New Zealand has been shown to be capable of transmitting RRV under laboratory conditions (Maguire1994). The potential for other competent vector species in New Zealand is unknown.

The likelihood of a competent vector mosquito biting a viraemic imported marsupial and then transmitting RRV or BFV to susceptible animals or humans is very low.

11.2.3. Consequence assessment

The significance of importing marsupials infected with RRV or BFV would probably be related only to its zoonotic potential. The number of potentially infected humans from Australia far exceeds the number of marsupials imported annually.

Serological studies have shown that RRV has probably been introduced into New Zealand by viraemic travellers on many occasions. There has been no evidence of local spread or establishment of virus from the imported cases (Maguire 1994). The clinical syndrome in humans is mild, and resolves over time.

There are currently no risk management measures applied to importation of horses potentially infected with RRV from Australia, and no incursions have been reported.

Therefore, the likelihood of significant consequences is assessed to be negligible.

11.2.4. Risk estimation

Because the consequence assessment is negligible, the risk estimate for RRV and BFV is negligible, and the viruses are not assessed to be a risk in the commodity.

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12. *Bartonella australis*

12.1. HAZARD IDENTIFICATION

12.1.1. Aetiological agent

Family: *Bartonellaceae* Genus: *Bartonella* Species: *B. australis*

12.1.2. OIE list

Not listed.

12.1.3. New Zealand status

Exotic. Other *Bartonella spp.* are present in New Zealand, *B. henselae* and *B. clarridgeiae* (Kelly *et al.* 2005).

12.1.4. Epidemiology

B.australis is a facultative intracellular gram-negative bacterium. *Bartonella spp.* are transmitted by insect vectors such as ticks, fleas, sand flies and mosquitoes. They produce a wide range of symptoms in humans, but fever and endocarditis are most common (Boulouis *et al.* 2005).

In 1999, three *Bartonella* isolates were cultured from the blood of 5 eastern grey kangaroos from central coastal Queensland. Multigene sequencing revealed these *Bartonella* isolates to be a new species, which was subsequently named *Bartonella australis* (Fournier *et al.* 2007). It is the first *Bartonella spp.* to be isolated from marsupials, and has only been isolated from wild eastern grey kangaroos. Prior to this isolation, only *B. henselae* and *B. quintana* were known to be present in Australia.

Little is known about its epidemiology and pathogenicity in animals (AWHN 2008). The pathogenicity in humans is also unknown, but one strain was associated with a phylogentic cluster containing species that can infect humans (Fournier *et al.* 2007).

A number of haemoparasites are known to affect Australian mammals. In many cases the identity of these parasites has not been determined and their epidemiology and pathogenicity are not known (Mackerras 1959). It is not known if this parasite is responsible for the syndrome of anaemia and deaths associated with the presence of an unidentified haemoparasite that is recognised in eastern grey kangaroos in northern coastal New South Wales (AWHN 2008).

B. australis can be diagnosed by culture or PCR. It was found to be susceptible to a wide range of antibiotics (Fournier *et al.* 2007).

12.1.5. Hazard identification conclusion

Eastern grey kangaroos can be infected with *B.australis.* The competency of potential vectors in New Zealand, and the pathogenicity in humans is unknown. Therefore *B.australis* is identified as a hazard in the commodity.

12.2. RISK ASSESSMENT

12.2.1. Entry assessment

The prevalence of *B. australis* infection is unknown. It is not known if species other than eastern grey kangaroos can be infected. Significance, time course, and vector of infection is also unknown, however *B. australis* has not been identified as a problem within captive macropod populations. Therefore the likelihood of introducing infected animals is very low.

12.2.2. Exposure assessment

A viraemic animal introduced into New Zealand would not be directly infectious. *B.australis* could only be transmitted to other animals or humans in New Zealand by competent insect vectors. The vector species in Australia and the potential for competent vector species in New Zealand is unknown.

The likelihood of a competent vector species biting a viraemic imported macropod and then transmitting *B.australis* to susceptible animals or humans is assumed to be very low.

12.2.3. Consequence assessment

If *B.australis* is the causative agent of anaemia and deaths in eastern grey kangaroos, then imported infected macropods could suffer this consequence, and if competent vector species occur in New Zealand then the naïve captive macropod population could also be affected. However, as *B.australis* infection has only been identified in wild eastern grey kangaroos in Australia, it could be assumed that if infection is present in captive populations, the significance and consequences are negligible.

It is not known if *B.australis* is pathogenic in humans, and there have been no reports of human infections in Australia. If human infection did establish in New Zealand, given the minimal likelihood of macropod-vector-human exposure it would be highly unlikely to significantly increase the prevalence of Bartonellosis in the New Zealand population.

Therefore, the likelihood of significant consequences is negligible.

12.2.4. Risk estimation

Because the consequence assessment is negligible, the risk estimate for *B.australis* is negligible, and the organism is not assessed to be a risk in the commodity.

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13. *Burkholderia pseudomallei* (Melioidosis)

13.1. HAZARD IDENTIFICATION

13.1.1. Aetiological agent

Family: *Burkholderiaceae* Genus: *Burkholderia* Species: *B. pseudomallei* (formerly *Pseudomonas pseudomallei* and *Malleomyces pseudomallei*).

13.1.2. OIE list

Not listed.

13.1.3. New Zealand status

Exotic, listed on the unwanted organisms register.

13.1.4. Epidemiology

Melioidosis is a disease of man and animals that occurs predominantly in the tropical and subtropical regions of Asia and northern Australia, with some foci in Africa (Groves and Harrington 1994). A human case has occurred in New Zealand in a traveller returning from Fiji (Corkill and Cornere 1987).

B.pseudomallei occurs in the environment and is widely distributed in water and soil (Sprague and Neubauer 2004). It has been transmitted to animals via oral and nasal mucosa, ingestion, parenteral inoculation, and skin scarification (Groves and Harrington 1994). Infection in natural cases is by contact with infected water and mud especially through abrasions and wounds. Water was implicated as a possible source of infections in six locations in one study (Inglis *et al.* 2004).

A wide range of animals can be infected, but clinical melioidosis is most commonly seen in sheep, goats and pigs. The agent may cause a wide variety of signs and lesions, varying from septicaemia and acute respiratory infections to localized abscesses (Low Choy *et al.* 2000).

Although serological surveys indicate that melioidosis is widespread in Australian native land mammals, infection rates are not high, and there are few reports of clinical disease (Ladds 2008). It has caused the deaths of several wallabies of an unidentified species that were exported from Australia to Malaysia (Saroja 1979). There was one death of a free-living koala, and 16% from the same colony tested were clinically healthy but serologically positive for *B. pseudomallei* (Ladds *et al.* 1990).

In humans, *B. pseudomallei* primarily infects those with impaired immunity and is believed to have a low disease-causing potential in healthy hosts. Disease does not spread from person to person (Cheng and Currie 2005).

Zoonotic transmission is extremely unusual (Low Choy *et al.* 2000). Transmission from animal to animal has not been described.

13.1.5. Hazard identification conclusion

Burkholderia pseudomallei is an organism found very widely in the environment in tropical and subtropical areas, but has not established in temperate climates. It appears to be an opportunistic pathogen and direct transmission from animal to animal is not described, and from animal to human is extremely rare. Therefore, it is not identified as a hazard in the commodity.

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14. *Coxiella burnetii* (Q fever) and *Rickettsia* spp.

14.1. HAZARD IDENTIFICATION

14.1.1. Aetiological agent

Coxiella burnetii and *Rickettsia* spp. are obligate intracellular gram-negative bacteria.

14.1.2. OIE List

Listed as a disease of multiple species but there is no chapter on the disease in the OIE Code.

14.1.3. New Zealand status

Coxiella burnetii is an exotic, notifiable unwanted organism. Most *Rickettsia* spp. are exotic, unwanted organisms, *R. felis* and *R. typhi* are endemic (Kelly 2005).

14.1.4. Epidemiology

Coxiella burnetii infection occurs worldwide with the exception of New Zealand (Worthington 2001) and Antarctica (Arricau-Bouvery and Rodolakis 2005).

Q fever occurs widely throughout Australia, with southern Queensland, northern and western New South Wales reporting higher levels of infection in people (Garner *et al.* 1997).

C. burnetii probably infects all mammalian species, birds and many arthropods, but mainly affects cattle, sheep, goats, and humans (Rousset 2004). Within Australia, native and feral wildlife species implicated as likely reservoirs include bandicoots, kangaroos, small rodents, feral goats and possibly pigeons (Garner *et al.* 1997).

Infection in wildlife is most likely to stem from direct contact with contaminated fomites, such as faeces or birth products. A tick-vertebrate-tick cycle also exists, and isolation of *C. burnetii* was achieved from 13 *Amblyomma triguttatum* kangaroo ticks (Pope *et al.* 1960).

All species infected with *C. burnetii* may act as carriers of the organism, shedding intermittently over prolonged periods of time in urine, faeces, colostrum and milk. Shedding is heaviest at parturition (AWHN 2009). Wildlife species do not exhibit clinical signs of infection, although they are capable of shedding large numbers of the organism. Out of 270 macropods tested, 18% were found to be antibody positive (Pope *et al.* 1960). Experimental infection in bandicoots (*Isoodon torosus)*, a likely reservoir host in Australia, produced no clinical signs of disease or febrile response (Derrick *et al.* 1939).

Overseas, morbidity and mortality is extremely low in wildlife species and the incubation period is also considered variable (CFSPH 2007). Although not reported in published literature, morbidity and mortality rates in Australian wildlife are likely to be similarly low due to the subclinical nature of *C.burnetii* infection in these species (AWHN 2009).

In domestic animals the infections are of minimal economic importance and rarely cause disease, but *C. burnetii* is a zoonotic organism that sometimes causes serious disease in humans. The typical incubation period is 2-3 weeks (CFSPH 2007). Most human infections are asymptomatic or present as a mild flu-like condition, but acute or chronic infections

sometimes occur and some of these result in serious complications such as myocarditis, endocarditis, hepatitis and renal failure. *C. burnetii* also causes sporadic abortions in both humans and animals (Maurin 1999; Arricau-Bouvery 2005).

The infection is diagnosed by serological tests or by isolation of the organism (Arricau-Bouvery 2005). The antibody detection ELISA tends to replace the IFA and CF test as the test of choice for veterinary diagnosis because it is convenient for large scale screening in various animal species (Rousset 2004). It is important to recognise that positive serology does not correlate with shedding of the organism.

PCR can be used to detect *C. burnetii* in milk, colostrum, aborted material and faeces. In subclinical wildlife carriers, testing of faecal material will produce the best results. An advantage of this method is that samples can be heat inactivated, ensuring their safety within the laboratory. PCR is the most rapid and sensitive way of detecting animals who are shedding. Combining an ELISA with faecal PCR is the most effective method of diagnosing *C. burnetii* infection in wildlife species (AWHN 2009).

There are no effective treatment regimes described for chronically infected marsupials and monotremes.

Undefined *Rickettsia* spp. occur in a wide range of Australian native marsupials, but clinical disease is mild or inapparent, and pathological changes have not been recorded (Ladds 2008). A *Rickettsia* spp. described as '*Anaplasma marginale*-like' has been identified in circulating red blood cells of normal echidna (Whittington 2008).

14.1.5. Hazard identification conclusion

C. burnetii is an exotic, notifiable and zoonotic organism. It is endemic in Australia and subclinically infects most marsupials and monotremes. Therefore, it is identified as a hazard in the commodity.

There is no evidence that *Rickettsia* spp. infecting marsupials and monotremes are pathogenic, or that they can be transmitted to other species. Therefore, they are not identified as a hazard in the commodity.

14.2. RISK ASSESSMENT

14.2.1. Entry assessment

Wildlife species do not exhibit clinical signs of infection with *C. burnetii*, but they are capable of shedding the organism intermittently over prolonged periods of time.

Therefore, the likelihood of entry is assessed to be non-negligible.

14.2.2. Exposure assessment

Imported marsupials and monotremes will be held in containment facilities, so the likelihood of exposure is limited to zoo staff, wild birds and rodents that may access their enclosures.

It is not known whether the New Zealand cattle tick can become infected but since at least 40 species of ticks can be infected (Maurin 1999), the likelihood that *Haemaphysalis longicornis* could be infected with the organism is assessed to be non-negligible.

There is no evidence that humans have been infected with *C. burnetii* by marsupials or monotremes, but if exposed to an appropriate infective dose there is no reason to believe transmission would not be possible. It is likely that the risk of exposure of humans in New Zealand as a result of the importation of zoo animals from Australia will be significantly lower than the risk posed by the thousands of tourists who travel to and from Australia each year.

Therefore the likelihood of exposure is assessed to be low.

14.2.3. Consequence assessment

Establishment of *C. burnetii* would have negligible consequences for other wildlife species held in zoos as infection is usually subclinical.

There is a low likelihood that the introduction of *C.burnetti* into a naïve livestock population might cause some abortions. The New Zealand cattle tick may have the potential to become a vector for disease and contribute to the organism becoming endemic.

Establishment of the organism would result in sporadic cases of serious disease in humans, therefore the consequences are assessed to be non-negligible.

14.2.4. Risk estimation

Since entry, exposure and consequence assessments are non-negligible, the risk estimate for *C. burnetii* is non-negligible and it is assessed to be a risk in the commodity.

14.3. RISK MANAGEMENT

14.3.1. Options

The following measures could be considered in order to effectively manage the risk:

- Since potentially infected humans, and zoo animals (including macropods) have been imported into New Zealand from many countries for many years, it may be likely that *C. burnetii* has already been introduced into New Zealand. Given that Q-fever has not become established here, it could be considered that no restrictions are necessary.

- Suitable measures could be implemented to prevent the importation of ticks on the commodity (see Section 21).

  This option does not provide protection against the importation of *C. Burnetii* except for the prevention of the importation of infected tick vectors.

- Marsupials and monotremes for export could be maintained tick-free and quarantined in tick-free premises for at least 21 days; AND

  Test negative by an antibody detection ELISA within the 5 days prior to shipment.

- Marsupials and monotremes for export could be maintained tick-free and quarantined in tick free premises for at least 21 days; AND

  Test negative by an antibody detection ELISA within the 5 days prior to shipment; AND

  Have a faecal sample collected and tested by PCR within the 5 days prior to shipment with negative results.

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15. *Leptospira* spp.

15.1. HAZARD IDENTIFICATION

15.1.1. Aetiological agent

Before 1989 in the accepted taxonomic scheme, all pathogenic serovars belonged to the species *Leptospira interrogans* which contained more than 200 serovars in 23 serogroups. More recently the genus has been re-organised and pathogenic leptospires are now identified in several species of *Leptospira* (CFSPH 2005). However for the purposes of this risk analysis, serovars are written as if they were single species e.g. *Leptospira hardjo, L. pomona* etc.

15.1.2. OIE list

Not listed

15.1.3. New Zealand status

L. hardjo, L. pomona, L. balcanica, L. copenhageni, L. ballum, and *L. tarrasovi* have been isolated from animals in New Zealand (Midwinter 1999). Single isolations of *L. australis* and *L. canicola* have been reported from humans (Thompson 1980; Chereshky *et al*. 1993). In humans, serological diagnosis indicates that five of the species endemic in farm animals infect humans but *L. balcanica*, which is associated with possums, has not been diagnosed in humans (ESR 2003). A serosurvey of 8,730 dogs throughout New Zealand found only one weak reaction to *L. canicola,* and it is concluded that this serovar is not present here (Hilbink *et al*. 1992).

Other *Leptospira* spp. are classified by MPI as 'other exotic organisms'

15.1.4. Epidemiology

Leptospirosis occurs world-wide but the endemic serotypes that occur in each country differ. It is not a single disease but a complex of diseases caused by at least 200 different organisms. Many *Leptospira* serovars are adapted to a particular host species in which an almost symbiotic relationship has been formed. Species other than the maintenance host may be more resistant to infection but if infected are more susceptible to disease. *L. hardjo* for example infects most cattle in an endemic situation but only causes occasional cases of disease in cattle. However, it may be responsible for causing sporadic cases of disease in other species such as man (accidental hosts).

In maintenance hosts, *Leptospira* may localise in the kidneys and the animals may continue to excrete the organism in their urine for years. Cattle can remain carriers of *L. hardjo* for at least 450 days (Hunter 2004). In New Zealand the prevalence of the disease in humans is relatively high for a temperate climate country and *L. hardjo* accounts for nearly half the cases (Thornley *et al*. 2002). *L.hardjo* is also the most common serovar in Australia (VGHI 2008). Of 230 serovars identified, only 22 have been isolated in Australia (AQIS 2000).

Leptospirosis can be transmitted either directly between hosts or indirectly in the environment. Direct transmission occurs through contact with infected urine, venereal and placental transfer, bite wounds or ingestion of infected tissues. The organisms usually enter

the body through mucous membranes or abraded skin (CFSPH 2005). Indirect transmission occurs through exposure to water, soil, food or bedding contaminated with infected urine. Diseased animals shed more organisms and are more important sources of infection than chronic carriers (Horsch 1989). In accidental hosts the incubation period may be from 2-16 days and is followed by a period of bacteraemia. A variety of signs may be shown by diseased animals including abortion, haemolytic anaemia, icterus, and nephritis.

Infection by *Leptospira* is common in a wide range of wild mammals, but disease has rarely been reported in free-ranging wildlife (Leighton and Kuiken 2001). Among marsupials, only brushtail possums have been identified as maintenance hosts for *Leptospirosis* in Australia (Eymann *et al.* 2007). Antibodies against *leptospires* have been demonstrated in various macropods, but no clinical disease or lesions have been reported (Ladds 2008). A small percentage of wombats are also subclinically affected (Skerrat 2008), but do not appear to be involved in transmission of disease (Hartley 2002).

Serovars z*anoni, australis* and *hardjo* accounted for 60.9% of all Australian notifications of leptospirosis in 2006. Rats and bandicoots are thought to carry *L.zanoni,* and rats and small marsupials are thought to carry *L.australis* (Symonds 2006). The overall prevalence in wildlife appears to be low, 3.7% of 184 marsupials tested with 11 *Leptospira* antigens in one study (Milner and Wilks 1981).

The disease can be diagnosed by the isolation of the organism, but because this is a slow process (taking up to 26 weeks dependent on serovar) it is more usually diagnosed by serological methods, with a rising titre signifying recent infection and a stable, often low titre indicating resolution or a chronic infection. The microscopic agglutination test is still the most commonly used test and can be used on a variety of animal species without modification. A number of variations of commercial ELISAs are also available but these generally lack serovar specificity (Bolin 2004).

Leptospirosis is seldom the cause of economically serious disease in animals and is mainly of concern because it is a zoonotic disease that occasionally causes serious disease in humans (Thornley *et al*. 2002). *Leptospira* spp. are sensitive to several antibiotics (Murray and Hospenthal 2004).

15.1.5. Hazard identification conclusion

A range of serovars can subclinically infect marsupials. *Leptospira* spp. other than the 6 endemic serovars are exotic, zoonotic organisms and are identified as a hazard in the commodity.

15.2. RISK ASSESSMENT

15.2.1. Entry assessment

Marsupials infected with *Leptospira* have no clinical signs. Acutely infected animals or chronic carriers may excrete the organism in urine. The prevalence of infection in marsupials appears to be low. Therefore the likelihood of entry is non-negligible.

15.2.2. Exposure assessment

Carrier marsupials shedding the organism in their urine could potentially infect wildlife accessing their enclosures, and zoo staff could be occupationally exposed. Venereal

transmission of the organism also occurs, so exposure of other marsupials through breeding programmes is also possible. Drainage run-off or contaminated waste material removed from enclosures could also contribute to potential exposure

The likelihood of exposure of New Zealand animals and humans to the organisms is therefore assessed to be low.

15.2.3. Consequence assessment

Introduction of new serovars of leptospira are unlikely to have a significant impact on the New Zealand animal population. Sporadic cases of disease may occur, but the economic consequences would be negligible.

The establishment of a new *Leptospira* serovar to which humans are susceptible could lead to sporadic occurrence of leptospirosis in humans. The number and seriousness of the cases would depend on the serovars involved and the possibility for contact with infected animals. Some serovars are not important as human pathogens e.g. in New Zealand and Australia *L. balcanica* is common in its maintenance host the brush tailed possum, but infections of humans have not occurred despite the close contact between possums and possum hunters (Anonymous 2004).

There are not likely to be noticeable consequences for feral or wild animals but some serovars such as *L. grippotyphosa, L. canicola, L.sejroe,* and *L. saxkoebing* could become established in mice and rats (Horsch 1989) and subsequently be responsible for infecting humans.

The establishment of new *Leptospira* serovars could cause sporadic cases of disease in humans. Therefore, the consequences of establishment are assessed to be low.

15.2.4. Risk estimation

Since entry, exposure and consequence assessments are non-negligible, the risk estimate for *Leptospira* is non-negligible and it is assessed to be a risk in the commodity.

15.3. RISK MANAGEMENT

At the OIE General Session in May 2009, the International Committee accepted the recommendation of the TAHSC that the empty *Code* chapter on leptospirosis should be deleted from the *Code*. The rationale for deletion was cited in the March 2009 report of the TAHSC:

"*Leptospirosis is distributed globally; it is improbable that any country can, with any credibility, claim to be free from the disease. Further, it is unlikely that any country has an official control programme for leptospirosis. Current serological tests and culture techniques are not able, with any degree of confidence, to demonstrate that an animal is free from leptospirosis. Antibiotic treatment to clear renal carriage of leptospires is not consistently successful and has not been validated in all the species subject to international trade. Retention of this empty Chapter, with the words 'under study' gives the false impression that the OIE is able to formulate meaningful measures to manage the disease*."

One or a combination of the following options could therefore be considered in order to effectively manage the risk associated with exotic *Leptospira* spp. in the commodity:

- Following the OIE conclusion, and in accordance with the *Review of Leptospirosis Measures in Import Health Standards* (MAF Biosecurity 2009), because the marsupial species covered by this risk analysis are not considered to be maintenance hosts for any *Leptospira* serovars, individuals could be imported without restrictions.

- Animals could be quarantined for 4 weeks and tested serologically on entry into quarantine and again after 2 weeks. Those that are serologically negative or clearly identifiable as having antibody that indicates infection or previous infection only with a serovar that occurs in New Zealand, could be imported.

- Animals to be imported could be treated with suitable antibiotics before shipment.

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16. *Salmonella* spp.

16.1. HAZARD IDENTIFICATION

16.1.1. Aetiological agent

There are approximately 2,500 known serovars in the *Salmonella* genus (Davies 2004). Most of the isolates that cause disease in humans and other mammals belong the species enterica and the subspecies enterica and if correct naming conventions are used, the names such as Dublin and Typhimurium, which do not have species status, should not be italicised. The correct name for the serovar *typhimurium* is *Salmonella enterica* subsp. *enterica* serovar Typhimurium. However, in the following discussion for the sake of simplicity names are italicised and abbreviated as though the serovar had species status e.g. *Salmonella typhimurium*.

Within each serovar there are multiple strains which can be identified by phage typing. In the case of *Salmonella typhimurium*, only the definitive phage type (DT) 104 is specifically considered in this analysis. *Salmonella typhimurium* DT104 is of particular significance because it exhibits multiple resistance to many antibiotics and is therefore a threat to human health (Hogue *et al.* 1997; Jones *et al.* 2002). It is now widely distributed in the world.

16.1.2. OIE list

Salmonellosis is not a listed disease in the OIE *Terrestrial Animal Health Code*. However, in the OIE *Manual of Diagnostic Tests and Vaccines* salmonellosis is included in the section "Diseases not covered by List A and List B".

16.1.3. New Zealand status

Salmonella Dublin, Salmonella abortusovis, Salmonella gallinarum, Salmonella pullorum are listed on the Unwanted Organisms Register as unwanted, notifiable organisms. While *Salmonella Arizonae, Salmonella enteritidis* DT4 , *Salmonella typhimurium* DT44 and 104 and Salmonella spp. (exotic affecting animals) are listed as unwanted "other exotic" organisms.

Salmonella spp. isolated in New Zealand from humans and animals, by all major laboratories, are identified to serovar and phage type by the Environmental Science and Research laboratory and recorded on a database (ESR 2009).

Salmonella typhimurium is endemic in New Zealand in both animals and humans, but DT104 has only been isolated very rarely from humans and not from livestock. It was once isolated from three dogs in a household where the owners suffered from diarrhoea after returning from an overseas visit (Julian 2002). The sporadic occurrence of *Salmonella typhimurium* DT104 in a few cases in humans and once in dogs does not suggest that it has become established in the New Zealand animal population.

16.1.4. Epidemiology

Salmonellosis can be found worldwide but serovars vary in their distribution. *Salmonella* spp. are mainly transmitted by the faecal-oral route. They are carried subclinically in the intestines or gall bladder of many animals, and are continuously or intermittently shed in the faeces. They can also be carried latently in the mesenteric lymph nodes or tonsils; these bacteria are not shed, but can become reactivated after stress. Vertical transmission occurs in birds within eggs, and can also be transmitted *in utero* in mammals (CFSPH 2005).

Excreted organisms contaminate the environment and become a source of infection via fomites (Blood *et al.* 1994). Salmonella spp. can survive for long periods in the environment, particularly where it is wet and warm. *S.typhimurium* and *S.dublin* have been found to survive for over a year in the environment (CFSPH 2005).

Factors such as infecting dose, the particular strain and species, and various stress factors influence the outcome of infection (Fenwick and Collett 2004). Young animals are more often affected by the disease than adults and may die after a short bacteraemia. The incubation period is variable but the organisms may be found in the bloodstream of newborn calves within 15 minutes of ingestion (Blood *et al.* 1994). The intestine is initially infected and inflammation of the gut is the primary lesion. Initial infection may be followed by invasion of the gut and mesenteric lymph node followed by bacteraemia and dissemination to many organs. In the case of pregnant animals abortion due to *S. dublin* may occur. Animals that recover from *S. dublin* infections frequently become carriers and may remain carriers for life, shedding organisms sporadically in their faeces. Animals infected with *S. typhimurium* may be carriers of infection for 3-4 months.

In Australia, a very large number of serotypes of *Salmonella* spp. have been isolated from macropods, but few reports relate particular isolates to clinical findings, and subclinical carriers are common. *S.typhimurium* appears to be the main serovar associated with illness, and has only been described in captive macropods (Ladds 2008). *S.typhimurium* has also been isolated from short-beaked echidna (Whittington 2008) and a septicaemic koala (Blanshard and Bodley 2008).

Carriers of infection can be detected by culturing faecal samples, but because excretion is intermittent repeated sampling and culture is necessary (Davies 2004). Serology may be useful but is best applied on a herd basis (Davies 2004; Veling *et al.* 2002). It has also been used for the identification of individual bovine carriers but its validity is influenced by age of the animal and is most valid for animals aged over 100 days of age (Nielsen *et al.* 2004). No practical method exists for detecting individual carrier animals (Hansen *et al.* 2006).

Treatment of infected marsupials suffering enteritis and sepsis has been attempted with parenteral antibiotics and fluids but while clinical signs may resolve, the animals may remain carriers (Vogelnest and Portas 2008).

16.1.5. Hazard identification conclusion

Salmonella serovars are distributed world-wide. A large variety of *Salmonella* serovars and phage types are already present in New Zealand and, although subclinical infection may occur, it is unlikely that healthy individuals would introduce an exotic *Salmonella* serovar or phage type.

Marsupials and macropods have not been implicated as playing an important role in the transmission of salmonellae to humans.

Reflecting the above, *Salmonella* spp. are not identified as a hazard.

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17. *Babesia* spp. and *Theileria* spp. (piroplasmosis)

17.1. HAZARD IDENTIFICATION

17.1.1. Aetiological agents

Undefined *Babesia spp.* macropods
Babesia tachyglossi short-beaked echidna
Theileria tacyhglossi short-beaked echidna

17.1.2. OIE list

Bovine babesiosis and theileriosis listed in "cattle diseases".

17.1.3. New Zealand status

Babesia spp. and *Theileria* (pathogenic species) are listed as unwanted notifiable organisms.

17.1.4. Epidemiology

Babesia and *Theileria* spp. are protozoal blood parasites transmitted by tick vectors.

Some species (*B.bovis, B.bigemina)* can cause serious disease in cattle, but *Babesia* spp. of cattle are not known to infect species other than cattle, African buffalo, and possibly some antelope species (Worthington and Bigalke 2001). Indications are that wild animals have their own *Babesia* spp., with varying degrees of host specificity, and that endemic stability generally prevails (Penzhorn 2006).

Babesia and *Theileria tachyglossi* are considered to be a common, incidental finding in healthy short-beaked echidnas (Whittington 2008).

There is one report of presumed *Babesia* infection in a rock wallaby unassociated with illness, and one report of *Babesia* parasitaemia in an anaemic eastern grey kangaroo (Ladds 2008).

Examination of blood smears is used for the diagnosis of acute infections, but in persistent infections the number of parasites in the blood is too low to be reliably detectable by this means. PCR tests may be available.

17.1.5. Hazard identification conclusion

Although *Babesia* and *Theileria* spp. may be a common finding on echidnas, these are considered to be indicental infections. The prevalence and/or significance of *Babesia* and *Theileria* spp. in other marsupials and monotremes appear to be negligible, and they are likely to be host specific. These piroplasms are therefore not identified as a hazard in the commodity.

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18. *Eimeria* spp. (coccidiosis)

18.1. HAZARD IDENTIFICATION

18.1.1. Aetiological agents

More than 40 species of Eimeria have been reported in macropods. *Eimeria kogoni* and *E. cunnamullensis* are most commonly associated with disease (Ladds 2008).

E. arundeli is associated with disease in wombats. Infections with *E.ursinus* or *E.wombati* are subclinical (Skerrat 2008).

E.echidnae, E.tachyglossi, and *Octosporella hystrix* are common in healthy echidna, but are also associated with disease (Barker *et al.* 1985).

18.1.2. OIE list

Not listed.

18.1.3. New Zealand status

Some coccidian species are present in New Zealand, including unidentified *Coccidia* spp. in wallabies and Kangaroos from Auckland Zoo (Potter 2009), and wallabies from Kawau Island (Duignan *et al*. 2004). *E.macropodis* oocysts were found in a wallaby from Hamilton Zoo (McKenna 2003).

18.1.4. Epidemiology

Coccidia are extremely common spore-forming protozoal parasites that infect the gastrointestinal tract of virtually all vertebrates. The disease is transmitted between hosts by contact with infected faeces or ingestion of infected tissue.

Most wild mammals examined are found to be infected with coccidia at one or more times in their life, and some may be persistently infected with several species that constantly cycle through them. Given the ubiquity of coccidia, it's likely that most are non-pathogenic under natural conditions. Coccidiosis is recognised as a health issue only during intensive husbandry, where transmission between hosts is enhanced by proximity (Duszynski and Upton 2001).

Clinical signs, when they do occur, are characterised by diarrhoea, fever, inappetance, weight loss, and sometimes death (Merck 1991).

Infection with coccidia in macropods is usually subclinical, but enteric coccidiosis is considered to be common in captive juveniles. Clinical disease is usually limited to animals less than one year old, and eastern grey kangaroos are most frequently affected. Hand-reared pouch young are considered particularly susceptible, as they lack passive immunity acquired from their dams (Vogelnest and Portas 2008). Coccidial cholangitis has been described in captive wallabies (Canfield and Hartley 1992).

Southern hairy-nosed wombats are the natural hosts for *E.ursinus* and *E.wombati*, and common wombats the natural hosts for *E.arundeli* (Barker *et al.* 1979). Although coccidial

oocysts are frequently identified in captive wombat faeces, clinical coccidiosis is uncommon. Disease is more common in juveniles, and can occur where there is a degree of host immuno-compromise or gastrointestinal dysfunction, or from a large infective dose due to unsanitary overcrowded conditions (Bryant and Reiss 2008).

Many healthy captive short-beaked echidna shed coccidial oocysts in their faeces. Coccidiosis may present as a spectrum from mild enteritis to fatal disseminated disease, often without premonitory clinical signs (Middleton 2008). Concurrent disease is often present. Diagnosis is usually by faecal flotation, and some treatment success has been achieved with toltrazuril.

18.1.5. Hazard identification conclusion

Coccidia are ubiquitous organisms, and many species are present in New Zealand mammals including macropods.

It is highly likely that coccidia associated with the import of marsupials and monotremes are host specific, and with adequate captive management are non-pathogenic. Therefore coccidia are not identified as a hazard in the commodity.

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19. *Leishmania*, *Trypanosoma*, and *Hepatozoan* spp.

19.1. HAZARD IDENTIFICATION

19.1.1. Aetiological agents

An undescribed species of *Leishmania* (a trypanosome protozoa) and other undefined *Trypanosoma* spp. have been identified in kangaroos.

Apicomplexan protozoa species have been identified in short-beaked echidna: *Hepatozoan tachglossi,* and an '*Atoxoplasma-like'* parasite which may be the same organism (Whittington 2008).

19.1.2. OIE list

Not listed.

19.1.3. New Zealand status

Leishmania and *Trypanosoma* spp. are notifiable, unwanted organisms.

19.1.4. Epidemiology

Leishmania and *Trypanosma* spp. are flagellated protozoan parasites that inhabit the blood and/or tissues of their hosts (Kocan 2001).

Leishmaniasis occurs in over 100 countries with climates that are warm-temperate through sub-tropical/tropical. Trypanosomatids require an insect host to complete their life cycles (Ross 1969). These parasites are naturally transmitted by sandflies of the genus *Phlebotomus* during feeding. Infection can be subclinical, cutaneous, muco-cutaneous or visceral (Gradoni and Gramicca 2004).

Leishmaniasis is considered a zoonosis, and humans are generally accidental hosts (Ashford 2000). The animal reservoirs of *Leishmania* are variable with respect to geography and species, but often include rodents, dogs, and other mammals. In Australia, only imported cases of leishmaniasis have been recorded in dogs and humans (Herwaldt 1999).

Ulcerative and papular skin lesions associated with an undescribed species of *Leishmania* have been reported from captive red kangaroos (Rose *et al.* 2004). Lesions occur on the pinnae, limbs, and tail of affected animals, and are usually chronic but occasionally self-resolve (Vogelnest and Portas 2008). The condition has not been detected in other macropods, humans, or other animal species. The vectors, host range, and source of *Leishmania* spp. in the infected animals are not known.

Infected animals exhibit variable levels of anti-*Leishmania* antibodies in serum detectable by ELISA. Organisms can be cultured from lesions, or identified by electron microscopy. Effective prevention and treatment strategies are unknown.

Other *Trypanosoma* spp. have been recognised in blood smears or by PCR in eastern grey kangaroos. The presence of trypanosomes does not appear to be associated with clinical disease or lesions (Ladds 2008).

Another unidentified haemoprotozoan parasite seems to be associated with severe anaemia and possibly clotting deficiency in young eastern grey kangaroos free-living in Northern New South Wales (Ladds 2008).

Hepatozoan tachyglossi is commonly identified in monocytes of clinically normal echidna (Whittington 2008). Members of the genus *Hepatozoan* possess particularly complex life cycles which vary considerably among species. No reports were found to indicate that this parasite is pathogenic, but it's presence in blood smears can confuse the diagnosis of systemic coccidiosis (Whittington 2008).

19.1.5. Hazard identification conclusion

One novel *Leishmania* species has been found in one species of macropod. It causes cutaneous lesions and requires a vector to transmit, most likely a *Phlebotomine* sandfly species. Sandflies that occur in New Zealand are *Simuliidae* species.

Many other species including humans potentially infected with leishmaniasis have entered New Zealand, but the parasites have not established, which indicates the absence of suitable vector species.

There is no evidence that other animals or humans could be infected by the *Leishmania* spp. identified in red kanagroos. Therefore, *Leishmania* spp. are not identified as a hazard in the commodity.

Trypanosoma spp. that can infect eastern grey kangaroos are non-pathogenic, with no evidence of transmission to other animal species or humans. The potentially pathogenic unidentified haemoprotoza species has not been recorded in captive macropods. Therefore, other *Trypanosoma* spp. are not identified as a hazard in the commodity.

It is highly likely that *Hepatozoan tachyglossi* complex lifecyle is species specific, and that the parasite is non-pathogenic. Therefore it is not identified as a hazard in the commodity.

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20. Internal Parasites

20.1. HAZARD IDENTIFICATION

20.1.1. Aetiological agents

Multiple genera of nematodes, trematodes, and cestodes have been identified in marsupials and monotremes.

20.1.2. OIE list

No parasites that may infect marsupials or monotremes are listed.

20.1.3. New Zealand status

Unidentified Strongyle and *Rugopharaynx* spp. nematodes have been recovered from kangaroos and wallabies in Auckland Zoo (Potter 2009).

The following nematodes were identified in wallabies in New Zealand (McKenna 1997):

Globocephaloides trifidospicularis
Labiostrongylus communis
Pararugopharynx protemnodontis
Rugopharynx australis
Rugopharynx longibursaris
Rugopharynx omega

20.1.4. Epidemiology

Internal parasites belong to three basic groups:

Nematodes (mainly intestinal parasites)
Trematodes (flukes)
Cestodes (tapeworms)

Nematodes
The prevalence, magnitude, and diversity of internal parasite species in Australian native mammals is extensive. More than 40 nematode species have been identified just in the forestomach of kangaroos. Most of these are of very low pathogenicity, even with heavy worm infestations (Ladds 2008).

Labiostrongylus spp. and *Rugopharynx* spp. are relatively common in the alimentary tract of macropods and there are usually no clinical signs (Ladds 2008). *Strongyloides* spp. are typically well-tolerated by the host and mortality has only been reported from captive macropod populations. *Globocephaloides* spp.are blood feeders and morbidity and mortality have been observed in both free-ranging and captive macropod populations (Vogelnest and Portas 2008).

Several other species occasionally cause lesions in macropods including *Cyclostrongylus* spp. (oesophagus), *Spirostrongylus* spp. (oesophagus and stomach), *Parazonialaimus collaris*

(stomach), *Filarinema* spp. (stomach and intestine), *Hypodontus* spp. (intestine), *Paramacropostrongylus toraliformis* (colon and caecum). In most cases however, these too are usually non-pathogenic (Ladds 2008).

A large number of *Trichostrongylid* nematodes in the genera *Nicollina, Tachynema,* and *Tasmanema* colonise the intestinal tract of echidna. Burdens may be high, and mortality can result from non-suppurative enteritis. *Parastrongyloides* spp. may be present but are unlikely to be pathogenic (Whittington 2008).

The colon of wombats is inhabited by large numbers of *Strongyloid* nematodes of the genera *Oesophagostomoides* and *Phascolostrongylus,* which feed on gut contents so are non-pathogenic. *Macropostrongyloides* appears to feed on blood so may therefore be a potential pathogen (Spratt *et al.* 2008).

Hepatitis and bronchitis caused by *Capillaria* spp.has been described in captive macropods and potoroos respectively. *Durikainema* spp. (cardiovascular nematodes) are regarded as an incidental finding in macropods (Ladds 2008), but high numbers found in koalas were thought to cause vascular and respiratory compromise (Spratt and Gill 1998). *Breinlia ventricola* was identified in red kanagaroos at a game meat abbatoir, and *Breinlia mundayi* was found causing serositis in body cavities of swamp wallabies (Ladds 2008).

Angiostrongylus cantonensis (rat lungworm) has been reported causing meningoencephalitis in several macropod species from parts of Queensland and Sydney (Vogelnest and Portas 2008). Macropods are abberant/accidental hosts, and there is no evidence that they can transmit infection.

A number of *Marsupostrongylus* spp. and related metastrongyles occur in the respiratory tract of many marsupials, but clinical signs are rare, and lesions due to infestation are microscopic (Ladds 2008).

Pelecitus roemeri (formerly *Dirofilaria roemeri*) is a connective tissue nematode found in at least 5 genera of macropodids. They appear not to cause illness, and are most often found in the knee either free in the subcutis or encapsulated, depending on stage of infection (Ladds 2008).

Cestodes

Many macropod species are intermediate hosts for *Echinococcus granulosus,* and swamp wallabies may be particularly susceptible. Hydatid cysts are found mostly in the lung and thoracic cavity, and less often in the liver or peritoneal cavity. Disseminated infection has also been reported (Ladds 2008).

Hydatid cysts have only been reported in common wombats from Victoria (Jenkins 2006). The low prevalence or absence of hydatid infection in lungs and liver of wombats from many areas implies that they are not an important intermediate host (Skerratt 2008).

Progamotaenia spp. are present in the intestine of macropods (where they are not associated with lesions) or the bile ducts of wombats or macropods where *P.festiva* is most commonly associated with lesions (Ladds 2008).

Linstowia echidnae and *Echidnotaenia tachyglossi* are non-pathogenic and commonly found in echidna (Whittington 2008).

Paramoniezia johnstoni and *Phascolotaenia comani* are large cestodes in the small intestines of wombats which appear to be non-pathogenic (Skerratt 2008).

Koalas are the specific host of *Bertiella obesa*, burdens can be heavy, but usually only cause problems in koalas debilitated by other disease processes (Blanshard and Bodley 2008).

Trematodes

In contrast to nematodes and cestodes, infections of Australian native mammals with trematodes are uncommon, and except for fascioliasis, reports of disease are rare (Ladds 2008). *Fasciola hepatica* is common in macropods, and endemic in New Zealand.

The apparent absence of trematodes in captive populations may be due to lack of a suitable snail intermediate host. Certain nematode species present in the wild may also be absent in regional captive populations for this reason.

Internal parasite infections are diagnosed by identification of eggs or hatched larvae in faeces. Reliance on diagnosis by faecal examination and treatment with anthelmintics has been the method specified for many years in New Zealand's live animal Import Health Standards and those of our trading partners. No other practical methods are available for this purpose. Identification of single species of parasites as part of a quarantine procedure is often not possible and the criterion generally used for imported animals is that they should be entirely free from all parasite eggs in the standard egg flotation method used when examining faeces from imported animals.

20.1.5. Hazard identification conclusion

The number of internal parasites that could occur in marsupials and monotremes are too many to be considered individually. Most are species specific, but as comprehensive surveys of parasites already present in New Zealand marsupial populations (including brush-tailed possums) have not been undertaken, it is not possible to say with certainty which are, or are not already here. There have been no reports of marsupial-specific parasites establishing in other potential hosts in New Zealand and so the actual risk to biosecurity is also unknown.

Since marupials and monotremes are predominantly wild animals and not regularly submitted to detailed examination it is likely that they could carry undescribed parasites. The Australian indigenous marsupials evolved over millions of years in isolation from animals on other continents. During this period the parasites they carried evolved with them and as a result many of the parasites are unique to their marsupial hosts. The rate of endemicity of marsupial parasites at the generic level is 36% for trematodes, 60% for cestodes and 76% for nematodes. However, at the species level endemicity is 96% for trematodes, 99% for cestodes and 97% for nematodes (Beveridge and Spratt 1996). Therefore, new species of parasites that may be identified are likely to be endemic parasites that are specific for their marsupial hosts and not pathogenic for domestic animals, humans or New Zealand feral or wild animals, except for introduced marsupials (possums and wallabies).

However, given the wide range of parasites potentially present in marsupials and monotremes and the uncertainty regarding their significance, it is reasonable to conclude that exotic parasites should be identified as a hazard in the commodity.

20.2. RISK ASSESSMENT

20.2.1. Entry assessment

New species of parasites could be introduced with infested/carrier animals that show no clinical signs. Therefore the likelihood of entry in imported marsupials and monotremes is assessed to be non-negligible.

20.2.2. Exposure assessment

Imported marsupials and monotremes will be integrated with New Zealand captive marsupials and monotremes and could shed eggs and larvae of internal parasites on pasture within enclosures. Humans, wild birds, rodents and other potential intermediate hosts accessing the enclosures could be exposed to the eggs/larvae. The likelihood of exposure is therefore assessed to be non-negligible.

20.2.3. Consequence assessment

New parasites could be introduced and become established in New Zealand. The parasites covered in this section are generally not considered to be significant pathogens. They are likely to be less pathogenic than parasites already established in New Zealand. Therefore the health consequences for potentially affected species are likely to be minimal. There have been no reports of parasite species present in marsupials and monotremes infecting humans.

The introduction of the hydatid *Echinococcus granulosus* would have negative consequences for dogs, humans, and New Zealands country freedom status.

Given the wide range of poorly characterised exotic internal parasites that can infect marsupials and monotremes, it is possible that potentially affected species (including intermediate hosts) have not yet been exposed, and so susceptibility and therefore consequences are unknown. Given this uncertainty, the consequences of introduction are assessed to be non-negligible.

20.2.4. Risk estimation

Since entry, exposure, and consequence assessments are non-negligible, the risk estimate for exotic parasites is non-negligible and they are assessed to be a risk in the commodity.

20.3. RISK MANAGEMENT

20.3.1. Options

One or a combination of the following measures could be considered in order to mitigate the risk of importing exotic endoparasites.

- Marsupials and monotremes for export to New Zealand could be treated with an endoparasiticide effective against nematodes and cestodes 7-10 days prior to entering pre-export isolation.
- Marsupials and monotremes for export to New Zealand could be held in quarantine for a period of 30 days in premises with an impervious washable floor or on an

impervious pad. While in quarantine soiled bedding could be removed at least every 10 days and floors could be washed by high pressure hosing or steam cleaning (note that this measure needs to be combined with a treatment option in order to be effective).

- Marsupials and monotremes for export to New Zealand could be treated with an endoparasiticide within 48 hours after entering pre-export isolation.

- The efficacy of the endoparasiticide could be checked 7-14 days after the endoparasite treatment by examining faeces samples from the treated cattle by the faecal floatation concentration/sedimantation method (Egwang and Slocombe 1982) and be required to give a zero roundworm and tapeworm egg count.

- Treatments and testing could be repeated on animals that have positive egg counts until they give a zero roundworm and fluke egg count, the anthelmintic type should be changed as necessary.

  In the case of surviving parasites larval cultures could be made, the parasites identified, and MPI notified of the results. Where pathogenic endoparasite spp. exotic to New Zealand are identified, the animals could be considered ineligible for importation until treatment has been demonstrated to be effective (or the organism is no longer considered exotic to New Zealand). Where endoparasite spp. identified are demonstrated to be non-pathogenic and/or species specific the animals may be considered eligible for import

- Within 3 days of export to New Zealand animals could again be treated with an endoparasiticide.

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21. External Parasites

21.1. HAZARD IDENTIFICATION

21.1.1. Aetiological agents

Various species of ticks, mites, lice, fleas, and flies have all been recovered from or associated with marsupials and monotremes

World wide there are around 170 species of Argasidae or soft ticks and 650 species of Ixodidae or hard ticks (Allan 2001). There are approximately 75 species of tick in Australia, the majority of which are Ixodidae (MedEnt 2003).

21.1.2. OIE list

Not listed. However, several tick species are vectors of diseases included in the OIE list.

21.1.3. New Zealand status

There are nine tick species in New Zealand, most of which are found on wild birds (Heath 1977). The cattle tick *Haemaphysalis longicornis* is the only one of economic importance to livestock and agriculture (Loth 2004).

All exotic ticks are notifiable under the Biosecurity Act 1993.

21.1.4. Epidemiology

Ticks

Ticks are blood-feeding external parasites of mammals, birds and reptiles. Ticks have many susceptible hosts and are important vectors of disease-causing agents for humans and animals throughout the world (Loth 2005). A broad range of organisms can be carried by ticks including bacteria, rickettsiae, protozoa and viruses. Some species of tick inject neurotoxins into their host while feeding causing paralysis and death. Blood taken up by the tick remains largely undigested, existing as a food reserve which is gradually consumed. Pathogens in the blood may survive for long periods in this environment (Grattan-Smith 1997).

An infected tick may carry a particular pathogen for life. A female tick can transmit some blood-borne pathogens to her eggs by transovarial transmission (through the eggs to the next generation of larvae) while other pathogens may only be transmitted transstadially (between development stages). Some pathogens can be transmitted transovarially and transstadially. For multi-host ticks, where each subsequent life stage must find a host and feed, it is possible to transmit tick-borne organisms to multiple hosts.

Argasid ticks have soft leathery bodies and feed for 5-25 minutes. The Ixodidae ticks are characterized by a hard body plate and a prolonged feeding time (Grattan-Smith *et al*. 1997). For example *Rhipicephalus sanguineus* may take up to 21 days to engorge (Soulsby 1969).

Ixodes holocyclus has been found on all marsupial and monotreme species. *I.holocyclus* is a three-host paralysis tick, and its distribution is roughly within a 20-kilometre band along the eastern coastline of Australia (MedEnt 2003) At least 2 other species of *Ixodes* tick have been incriminated as causing tick paralysis in Australian native mammals; *I cornuatus,* and *I hirsti* (Ladds 2008).

In red kangaroos shot in the wild, skins have been commercially downgraded due to attachment site lesions of *Amblyomma trigutattum,* and there is one report of neurological signs in a kangaroo immediately after engorgement of the kangaroo tick *Ornithodorus* [syn *Argas*] *gurneyi,* but in general the severe local and systemic responses that have been seen in man are not reported (Ladds 2008).

Exsanguination during heavy tick infestation with *I.holocyclus* and *Haemaphysalis* spp.can be an important cause of morbidity or mortality in koalas, and anaemia has been attributed to *I.tasmani* (Blanshard and Bodley 2008).

Aponomma auruginans, Ixodes tasmani, I. cornatus and *I.victoriensis* are often found on wombats. Tick burdens may be quite heavy, and a significant reaction to tick bites may occur (Skerrat 1998).

Aponomma concolour (the 'echidna' tick), *Amblyomma* and *Haemaphysalis* spp. have all been recorded on short-beaked echidna (Booth 2003).

Mites

Mites are minute relatives of ticks (Soulsby 1968). Trombiculid mites such as *Leptotrombidium deliense* in Queensland are vectors of scrub typhus, an acute rickettsial disease of humans (Lerdthusnee *et al*. 2002). Many species of trombiculid mites have been found on kangaroos and wallabies (Ladds 2008).

There are few reports of dermatitis in macropods associated with mites, and clinical signs can be highly variable. The dermanyssid mite *Thadeua serrata* has caused papular and crateriform lesions, with crusting and alopecia particularly on the limbs of several wallaby species (Skerrat *et al.* 2007). Mites can be demonstrated in deep skin scrapings or biopsies, and a course of treatment with ivermectin or moxidectin is usually effective (Vogelnest and Portas 2008).

Dermatological changes have been associated with various species of mite infestations in other marsupials and monotremes including *Odontocarus echidnus* in echidnas (Middleton 2008).

Sarcoptic mange is regarded as the major debilitating infectious disease of free-ranging common wombats, southern hairy-nosed wombats are much less affected. The wombat mange mite was designated *Sarcoptes scabiei* var. *wombati* despite being morphologically indistinguishable from other mammalian sarcoptic mites (Skerrat 1998). *Acaroptes vombatus* (skin) and *Raillietia australis* (ear canal) appear to be non-pathogenic (Doube 1981).

Demodex spp. have been identified in skin scrapings from a koala without clinical signs (Blanshard 1994), and caused bilateral peri-ocular alopecia in another koala which resolved after treatment with oral ivermectin (Vogelnest *et al.* 2000). An atopomeline fur mite

Koalachirus perkinsi (formerly *Austrochirus perkinsi)* infests koalas without clinical signs (Halliday 2000).

Lice

Lice are host-specific wingless insects in the order Phthiraptera (Soulsby 1968).

Wild macropods are infested by a wide range of lice spp. but none or very few clinical signs are apparent in mild cases of pediculosis. In severe cases, alopecia and pruritus with associated self-trauma may be evident (Turni and Smales 2001). Lice are rarely problematic in well-managed captive populations as treatment with ivermectin, moxidectin, or imidacloprid is effective in eliminating infestations (Vogelnest and Portas 2008).

Dasyurid lice are all biting lice belonging to the genus *Boopia* (Holz 2008), and *Boopia tarsata* commonly infests wombats but is usually non-pathogenic (Bryant and Reiss 2008).

In New Zealand, an unidentified louse-like ectoparasite was recorded on parma and tammar wallabies from Kawau Island (Duignan 2004).

Fleas

Fleas (order Siphonaptera) are small wingless obligate blood-feeding insects, and are host-preferential rather than host-specific (Kelly *et al.* 2005). Fleas act as intermediate hosts for cestode and filarial infections, and are capable of transmitting exotic disease causing agents, including *Yersinia pestis* and *Francisella tularensis* (Wall and Pitts 2005).

Echidnophaga spp. (the 'stickfast' flea) has been identified as a cause of lesions in a range of captive macropod species. As with domestic species, clinical signs in macropods include pruritus and alopecia, and anaemia may be present in severe infestations. The obvious presence of fleas and flea faeces in an animals coat is diagnostic, and topical treatment with imidacloprid or fipronil combined with environmental control is effective.

Echidnophaga spp. have been identified on all species of wombat, and *Lycopsylla nova* is frequently found on free-ranging common wombats (Bryant and Reiss 2008). *Echidnophaga* spp. also infest echidna, as well as *Pulex irritans, Bradiopsylla echidnae,* and *Stephanocircus dasyure* (Middleton 2008).

Cat fleas *Ctenocephalides felis* have been found incidentally on koalas. These fleas are endemic in New Zealand.

Flies

Larvae of the kangaroo bot-fly *Tracheomyia macropi* have been recorded in the trachea and occasionally bronchi/bronchioles of grey and red kangaroos, and some wallaby species. The parasite is considered to be of low pathogenicity with localised tracheal erythema and ulceration described only in heavy infestations (Portas and Spratt 2008).

The sandflies *Austrosimulium pestilens* and *Simulium ornatipes* cause intense facial irritation in various macropod species particularly after heavy rain or flooding. Topical pyrethrin-based insecticides for animals and environment is an effective preventative strategy (Vogelnest and Portas 2008).

The sheep blow-fly *Lucilia cuprina* has caused cutaneous myiasis (flystrike) in debilitated koalas (Bryant and Reiss 2008). This fly species is endemic in New Zealand.

21.1.5. Hazard identification conclusion

All except one species of tick are exotic to New Zealand. Many species are vectors of zoonotic diseases and can also cause production losses associated with parasitism of animals. Ticks have the potential to infest all mammals, birds and reptiles. Ticks are therefore identified as a hazard in the commodity.

A large range of other external parasites occur on marsupials and monotremes. There is potential for mites and fleas to cause dermatitis and vector zoonotic diseases, so these are also identified as a hazard in the commodity.

A louse-like ectoparasite has been recorded on wallabies in New Zealand. Lice and flies are of minimal pathogenicity, and are not reported to be vectors of other diseases. So they are not identified as a hazard.

21.2. RISK ASSESSMENT

21.2.1. Entry assessment

Marsupials and monotremes have the potential to carry exotic ectoparasite species present in Australia. Zoo animals in general are not considered a significant pathway for the introduction of exotic ticks, mainly due to small volumes of animals imported, and reduced exposure in captivity- particularly where zoos are not situated within known tick distribution zones. Pre-export inspection is required to be meticulous, but in some cases small tick larvae, burrowing mites, and evidence of flea infestation may be almost impossible to detect. Therefore the likelihood of introducing exotic ectoparasite species is assessed to be low.

21.2.2. Exposure assessment

Ticks, mites, and fleas can survive for long periods and can have many susceptible hosts. External parasites carried by imported marsupials and monotremes could leave their hosts and complete their lifecycle by infesting other zoo animals, humans, or wildlife that may access their enclosures.

As a similar climate exists in regions of the North Island of New Zealand, to the climate in the distribution zone of *Ixodes holocyclus,* it is reasonable to conclude that it could establish itself here (Loth 2005). Endemic mite and flea species are widespread in New Zealand, so it is reasonable to assume exotic species of these ectoparasites would be adaptable to a broader climate range.

The likelihood of exposure is therefore assessed to be low.

21.2.3. Consequence assessment

The major consequences of exotic tick, mite, and flea establishment are the direct effects of parasitism and toxicity; the possible introduction of exotic arthropod-borne diseases; and the increased risk of introduced exotic diseases being able to establish in New Zealand if suitable vectors are established here.

The parasitic effects of ticks, mites, and fleas in sufficient numbers can include anaemia as a result of blood ingestion, debilitation and skin disease associated with hypersensitivity and bacterial pyoderma (Irwin and Jefferies 2004). *I. holocyclus*, the Australian paralysis tick is one of the most toxic of all the world's paralysing ticks. It is the cause of paralysis and death in pets, domestic animals, mice and humans (Grattan-Smith 1997). Infestation of New Zealand ruminants would result in associated production losses as well as expenses incurred to control ticks.

Ticks present in Australia are capable of carrying and transmitting the *Rickettsia australis* organism, which causes rickettsial spotted fever (also known as Queensland tick typhus) and *Rickettsia honei* which causes Flinders Island spotted fever in animals and people. It is speculated but uncertain whether Australian ticks can carry and transmit *Borrelia burgdorferi*, so this potential risk is described as 'Lyme-like' disease (TAG 2005). It is not known if marsupials and monotremes would be capable of transmitting these diseases, but if the tick became established in New Zealand it would be likely to infest and/or infect other animal species.

If new ectoparasite species were to become established in New Zealand the likelihood of exotic arthropod-borne diseases establishing here at some point in the future is increased. The absence of tick borne diseases in New Zealand may be attributable to the limited vector potential of *H. longicornis.*

The effects on the health of humans and animals may be severe. If an exotic ectoparasite were to establish, eradication would be difficult and expensive. The consequences are therefore assessed to be non-negligible

21.2.4. Risk estimation

Since entry, exposure, and consequence assessments are non-negligible, the risk estimate for exotic ectoparasites is non-negligible and they are assessed to be a risk in the commodity.

21.3. RISK MANAGEMENT

21.3.1. Options

One or a combination of the following measures could be considered in order to mitigate the risk of importing exotic ectoparasite spp:

- Marsupials and monotremes could be treated with an acaricide, 7-10 days prior to entering Pre Export Isolation (PEI).

- Marsupials and monotremes could be treated during the 48 hours immediately prior to entering PEI with an insecticide/acaricide treatment regime that is effective against ticks, mites and fleas (e.g. topical fipronil or amitraz, with subcutaneous, oral, or topical ivermectin/moxidectin).

- Marsupials and monotremes could be held isolated for 30 days in quarantine premises with impervious washable floor and walls or on a fenced, impervious pad without walls and surrounded by a cleared area free from vegetation. Bedding should not be straw or plant material that could contain ectoparasite eggs and larvae. Inert materials

such as wood shavings or sterilised peat could be considered suitable. The animals could be fed rations that are free from potential contamination with ectoparasites, their eggs, larvae or nymphs.

- Marsupials and monotremes could have all the bedding on which they are housed removed every ten days during the quarantine period and, at this time, the walls and floor could be thoroughly cleaned, and sprayed with an acaricide.

- Marsupials and monotremes could be meticulously inspected for evidence of ectoparasites, at least 10 days after entering PEI. If still infested, the treatment could be repeated and animals inspected again at least 10 days later. Treatments and inspections could be repeated until the animals are found to be free from evidence of ectoparasites. The ectoparasiticide could be altered if the previously used treatment has not been effective.

- Marsupials and monotremes could be treated with an acaricide within the 3 days prior to shipment.

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22. Weed seeds

22.1. HAZARD IDENTIFICATION

22.1.1. Aetiological agent

All plant seeds and plant material.

22.1.2. OIE list

Not listed.

22.1.3. New Zealand status

Organisms of concern are all exotic plant seeds.

22.1.4. General considerations

Seeds are specifically adapted to survive unfavourable environmental conditions and most will at least survive from one growing season to another. Many will survive for several years and germinate when favourable conditions occur. Most seeds are highly resistant to dehydration, particularly those from plants adapted to survival in hot dry climates and most seeds retain viability better in dry conditions but some are specifically adapted to remain viable in water. *Mimosa glomerata* seeds survived 221 years in the herbarium of the Museum National d'histoire Naturelle in Paris. *Lupinus arcticus* seeds frozen in a leemings burrow that was dated as 10,000 years old germinated within 48 hours when placed in favourable conditions (Anonymous undated). Some seeds are adapted to environments subjected to periodic fires and survive or are activated by fires. Others are adapted to be dispersed by water including those that are adapted to salt water.

Weeds and weed seeds could be found attached to the hair or within skin folds of imported marsupials, or within the quills of imported echidna. Large seed heads and pieces of plant material would be easily visible and could be removed before shipment but small seeds may not be visible.

Weed seeds can survive passage through an animal's digestive system and be passed out in the faeces (Katovich undated).

Some plants can replicate asexually and are able to be grown from cuttings, and could grow from pieces of plants introduced on animals.

22.1.5. Hazard identification conclusion

It is concluded that weed seeds could be introduced on animal's coat, within skin folds, or in their faeces. Therefore weed seeds are identified as a hazard in the commodity.

22.2. RISK ASSESSMENT

22.2.1. Entry assessment

As seeds and plant material could be introduced attached to animal's coat, within skin folds and in faeces, the likelihood of entry in the commodity is assessed to be non-negligible

22.2.2. Exposure assessment

Weed seeds could become detached from the coat, dislodged from skin folds, or released in faeces. They are generally resistant to most environmental conditions and may remain dormant until conditions are favourable for germination. Therefore the likelihood that seeds could germinate and grow if released into a suitable environment is non-negligible.

22.2.3. Consequence assessment

As a result of the release of exotic weed seeds, exotic noxious weeds could be introduced and become established with subsequent deleterious effects on the environment and the economy.

This could include out-competing native flora and over-running pasture thereby reducing biodiversity and stock grazing areas. The cost and resources required to control can be significant, as seen with invasive exotic weeds already present in New Zealand.

22.2.4. Risk estimation

Since entry, exposure, and consequence assessments are non-negligible, the risk estimate for exotic weed seeds is non-negligible and they are assessed to be a risk in the commodity.

22.3. RISK MANAGEMENT

22.3.1. Options

One or a combination of the following measures could be considered in order to mitigate the risk:

- The marsupials and monotremes could be thoroughly groomed and then inspected for contaminating plant material immediately prior to entering pre-export quarantine.

- The marsupials and monotremes could be required to be certified as being clean, and free from obvious contamination with dirt, plant material and other organic matter on inspection prior to export.

- The measures appropriate to control the introduction of ticks would also greatly reduce the likelihood of introducing weed seeds. Housing the animals for a period of 30 days in facilities with clean impervious flooring on bedding that is not made up of grass hay or straw will reduce the risk contamination with weed seeds. Suitable bedding materials include wood shavings, sawdust, or sterilised peat. During the 30 days in quarantine the plant material eaten by the animals before they were introduced into the quarantine facilities, will have been either digested or passed out in the faeces. Regular removal of faeces and soiled bedding will reduce the likelihood that weed seeds will be present in faeces that could contaminate the animal's body surface.

- Feeding of processed pellets that are essentially free of weed seeds will ensure that the animals do not ingest new burdens of weed seeds.

- A review of passage times for weed seeds in the digestive tract of herbivores (Barton and Williams 2001) concluded that, to avoid the importation of most unwanted seeds in the digestive tracts of herbivorous animals destined for New Zealand, they should be fed a seed free diet for at least 10 days prior to their arrival in New Zealand. Cattle passed about half the seeds ingested by 2.5 days and most of them by 7 days. A few seeds were retained for up to 1 month in cattle. The wide variation around the mean seed-passage times was attributed to many factors such as individual animal effects, whether or not the animal was pregnant, and food intake. The most widely reported factor with potential applicability to quarantine protocol was faster seed-passage time in animals fed a high-quality diet.

- An import risk analysis of the importation of weed species by live animals (Ministry of Agriculture and Forestry 1999) recommended that animals should be held, pre-shipment, in areas free of weed species and fed on clean pasture or high quality feed. During transport, provision of high quality feed with little or no weed species contamination or feed that has been treated in such a way as to render seeds non-viable would mitigate the risks associated with the importation of live animals. Dung produced during transport could be safely disposed of, either enroute or on arrival in New Zealand.

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